STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

HEARINGS

BEFORE THE

SPECIAL SUBCOMMITTEE ON MINERALS, MATERIALS AND FUELS ECONOMICS

OF THE

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE

EIGHTY-THIRD CONGRESS

FIRST SESSION

PURSUANT TO

S. Res. 143

A RESOLUTION TO INVESTIGATE THE ACCESSIBILITY AND AVAILABILITY OF SUPPLIES OF CRITICAL RAW MATERIALS

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PART 1

United States Department of the Interior: Bureau of Mines

OCTOBER 20, 21, 23, AND 24, 1953

Printed for the use of the Committee on Interior and Insular Affairs

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STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

TUESDAY, OCTOBER 20, 1953

UNITED STATES SENATE, SUBCOMMITTEE ON
MINERALS, MATERIALS, AND FUEL ECONOMICS,
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to call, at 2 p. m., in the committee room, 224 Senate Office Building, Washington, D. C., Senator George W. Malone, Nevada, chairman of the subcommittee, presiding.

Present: Senator George W. Malone, Nevada (chairman of the subcommittee).

Also present: Jerome S. Adlerman, counsel to the subcommittee; George B. Holderer, subcommittee staff engineer.

Senator MALONE. The subcommittee will be in order. Our first witness will be Hon. Douglas McKay, Secretary of the Interior.

Mr. Secretary, we are glad to see you. We believe you have some of the best engineers in the world in your Department, and we are leaning heavily on them for the record of factual material, as you know already.

The Minerals, Materials, and Fuels Economic Subcommittee of the Interior and Insular Affairs Committee is working under Senate Resolution 143 of the 83d Congress, 1st session, which reads in part as follows:

> *Resolved*, That the Senate Committee on Interior and Insular Affairs, or any duly authorized subcommittee thereof, is authorized and directed—
>
> (1) to make a full and complete investigation and study of the accessibility of critical raw materials to the United States during a time of war;
>
> (2) to study and recommend methods of encouraging developments to assure the availability of supplies of such critical raw materials adequate for the expanding economy and the security of the United States.

The full resolution as well as the Senate Report 689 of the Senate Committee on Rules and Administration approving the resolution is made a part of the record and will appear in the appendix as A and B.

AVAILABILITY IN TIME OF WAR

Under the terms of the resolution, the Minerals, Materials, and Fuels Economic Subcommittee of the Interior and Insular Affairs Committee, is charged with the double-barreled responsibility of ascertaining the accessibility of the critical materials to the United States in time of war as well as the availability of these materials for the expanding economy and the security of the United States.

It is imperative, therefore, that the committee study include: First, principles that will result in going concern industries and maximum productions in this Nation; second, the Western Hemisphere production of these materials and in addition, determine our ability to keep the oceanic lanes open to any foreign areas where such materials are available.

HEARINGS

The committee has held hearings in Washington, D. C.; Seattle, Wash.; Henderson, Nev., and will hold further hearings in Los Angeles, Salt Lake City, and again in Washington, and such other places where it may be necessary to go to get the facts essential to the committee for the formation of its findings and recommendations.

DEPENDENCY UPON FOREIGN NATIONS

The committee has heard testimony of engineers and producers in the mining industry as well as numerous Government officials. Some of these hearings were in executive session, closed to the public, due to security precautions, particularly those which related to the stockpiling of strategic materials necessary for the defense of the United States. The testimony received by the committee has revealed a shocking shortage of certain strategic and critical materials in the national stockpile which will be handled in a separate hearing.

We have become dependent upon foreign nations across one or both major oceans for many of the materials without which we cannot fight a war or support our economic structure.

STOCKPILE—OFFSHORE CONTRACTS

Although the stockpile program was originally scheduled to be completed by 1951, the completion date was extended to 1953 and it is now doubtful whether the stockpile program can be completed by 1958.

Examination of current contracts for strategic materials, conducted in secret sessions, showed that contract terms were more favorable to foreign producers than the terms given to domestic American producers. This favoritism to foreign producers is contrary to the intention of the stockpile law and to the security of the Nation. The best stockpile avialable to the United States in time of need is an economically healthy domestic industrial structure able to produce the materials essential to this country in time of war—in short, going concern mining, petroleum, textiles, watch, precision instruments, machine, and other industries.

The hearings have indicated an alarming dependence on foreign countries for strategic materials due to the failure of the past administrations to adopt a domestic policy which would develop the natural resources of the United States.

If we become embroiled in another global war, we would be dependent upon foreign sources for strategic materials without which we could not defend ourselves. These materials would have to be transported from ports within striking distance of the enemy planes, and across oceans infested with enemy submarines.

LINES OF TRANSPORTATION

Many top military strategists believe it will be impossible to keep the long sea lanes open to shipping in time of war. There is also grave doubt of the availability of critical materials in time of global warfare due to the political background of some of the countries supplying these materials.

The most important factors adversely affecting production of the critical materials in this country are: the 1934 Trade Agreements Act, Restrictions on venture capital by the Securities and Exchange Commission, and our failure to adopt adequate tax relief to new ventures for exploration and development of our natural resources.

With the new technique in atomic bomb and submarine warfare it is believed that transportation across either major ocean will be, to say the least, uncertain.

For example, most of this Nation's current supply of manganese comes from India, whereas if proper measures are taken in time, western hemispheric production can be increased to such an extent that we can become self-sufficient for our total war needs. It is imperative that the shortsighted policies of past administrations favoring foreign instead of domestic sources for this mineral must be reversed.

The committee expects in the near future to receive testimony on the past policy of the State Department which culminated in the dependence of the United States on foreign sources of supply for strategic materials essential to the security of the United States.

INTERNATIONAL CARTELS

Hearings will be held on the subject of the International Materials Conference, and the projection of international cartels sired by the State Department, coupled with the diversions and withdrawals from the national defense stockpile of materials vital to the defense of the country and which had a detrimental effect on the domestic market. This policy contributed to the almost complete destruction of the lead and zinc and other critical material markets for domestic production in the United States.

RETARDED DOMESTIC PRODUCTION

Specifically, complaints have reached the committee that domestic production has been retarded on five major fronts:

1. Trade agreements made by the State Department—under the 1934 Trade Agreements Act—called reciprocal trade.
2. Taxes, both direct and indirect.
3. The regulations of venture capital investments by the Securities and Exchange Commission.
4. The policy of favoring the purchase of foreign minerals and materials over domestically produced products under the Stockpile Act.
5. The manipulation of their currency and participation by foreign governments for trade advantage both here and in their own areas.

First, article I, section 8 of the Constitution of the United States provides that "Congress shall have the power to lay and collect * * * duties, imposts and excises" (tariffs or import fees) and "to regulate foreign commerce"; and

The Congress, through the 1934 Trade Agreements Act, transferred its constitutional responsibility to regulate foreign trade, through the adjustment of the duties, imposts, and excises—commonly referred to as tariffs and import fees—to the executive branch of the Government.

The question posed then in regard to the regulation of foreign trade is whether or not Congress should resume its constitutional responsibility through allowing the 1934 Trade Agreements Act to expire on June 12, 1954.

Second, excessive income and indirect taxes are alleged to discourage the investment of venture capital—and that the progressive higher brackets of income taxes dampen the incentive for the continued maximum production of going concern producers for the calendar year.

Third, claim is made that the interpretation of the Securities Exchange statute by the administrators of that act that they must in some manner determine the feasibility of the contemplated investment before giving their approval to a stock issue—and through public announcement of an investigation of such investments upon unstable grounds has retarded the investment of venture capital.

Fourth, it is alleged that definite policy of favoring the purchase of foreign minerals and materials over domestically produced products under the Stockpile Act—where producers do not pay American wages or American taxes has discouraged the investment of venture capital in such domestic enterprises and has caused unemployment, and the abandonment of mines, mills, and factories in this country, which has resulted in a serious loss of our defense potential.

Fifth, complaint has reached the committee that currency manipulation and government participation in trading operations by foreign nations, including empire preferential rates, has reacted to the disadvantage of American producers.

Senate Resolution No. 143 directs this committee to determine the "accessibility of critical raw materials to the United States in time of war * * * to assure the availability of supplies of such critical raw materials adequate for the expanding economy and the security of the United States."

It is of great interest, then, to this committee and to the United States Senate why we find this Nation dependent upon foreign nations across one or both major oceans for many such raw materials without which we cannot supply our plants and factories in war or in peace—where eminent military strategists agree that transportation of such materials to this country in time of war would be problematical, to say the least.

DOMESTIC RESOURCES OF STRATEGIC MATERIALS

Today's hearings will be devoted to testimony from Secretary of the Interior Douglas McKay and Assistant Secretary of the Interior Felix Wormser, and from engineers and officials of the Bureau of Mines of the Department of the Interior on the productive capacity of the United States, the Western Hemisphere, and other nations in

the world, of critical materials both in peace and wartime on going concern domestic industries; therefore, I am going to ask you this general question: Are you prepared to tell us today what is the policy of the Department of the Interior in the development of strategic and critical minerals and materials under your jurisdiction?

STATEMENTS OF HON. DOUGLAS McKAY, SECRETARY OF THE INTERIOR, AND HON. FELIX E. WORMSER, ASSISTANT SECRETARY OF THE INTERIOR, WASHINGTON, D. C.

Secretary McKay. Senator, in the first place, I had a little plane trouble last night, and I did not get too much sleep, so I come here unprepared. I want to make the general statement I appreciate the kind words you said about the career people in the Department, the engineers, and also Mr. Wormser. I share that opinion. As a matter of fact, I am told that the Department of Reclamation is the largest employer of engineers in the world. I think we have some of the very best engineers any place in Reclamation, in the mining department, and also some of the best scientists.

Senator Malone. I agree with you. I might say right at that point, one of your scientists—Dr. Wortman, who has worked for the Department many, many years—testified at the 2-day hearing at Henderson about 3 weeks ago. He gets credit by the engineering fraternity for perfecting the metal titanium. It is a tremendous thing. I would like very much to see him recognized in your Department some way or another.

Secretary McKay. Write me a note so I will not forget that.

Senator Malone. They are really doing a fine job.

Secretary McKay. They are doing a fine job. I am not a mining man, but we have some people that are in the Department that are very good. I want to say this, that the whole Department of Interior stands ready to cooperate with an committee in the Congress or with other executive departments in Washington, because we have many problems and many of them are mutual. All of our facilities and people are available in any way you want to use them, and you may call on them as you choose. So we will cooperate in every way possible.

Another thing, I think I better introduce Mr. Wormser, because he is the fellow who has the answers better than I. I might add Felix Wormser graduated from Columbia University in 1916. His first job was a mucker, in Baker, Oreg. That is back when gold was worth mining. He got $75 a month.

Senator Malone. You know, Mr. Secretary, gold represented money, and money represented gold.

Secretary McKay. I would say so. Felix got $75 a month. So all these 37 years he spent in the mining business. He is a trustee of Columbia University. He is recognized in the profession of mining engineers, and in the industry as a man of integrity and ability. He has appeared at many, many meetings over the United States. He has written papers. He has a very brilliant record in business. I think we are particularly fortunate to have a man of his ability from private enterprise to serve as Assistant Secretary in the Department of Interior. I am very happy to present him to you, and let hira

answer the questions. He probably knows the answers better than I do.

Senator MALONE. We are glad to see you, Mr. Assistant Secretary Wormser. I might say before you leave that we are excusing you today from making any extensive statement, but we hope that on your return from the west coast you can appear before the committee again.

Secretary MCKAY. I will be glad to.

Senator MALONE. While we are discussing the engineering profession, you have an Under Secretary, Mr. Tudor, whom I regard as one of the outstanding engineers on the Pacific coast. I am very glad and very happy to see the policy changed of putting administrators in engineering jobs. Of course, you have an administrative job, Secretary McKay.

Secretary MCKAY. That is right. I am not an engineer.

Senator MALONE. I might ask you, Mr. Secretary, before we start with Mr. Wormser, are you familiar in general with the present plight of the domestic mining industry?

Secretary MCKAY. Yes, sir; particularly lead and zinc.

Senator MALONE. I think many other industries such as tungsten, mercury, manganese, and others that we will go into in greater detail with your people, are in practically the same condition and for the same reason. We have developed in our hearings here with the Defense Materials Procurement Agency, which has now been transferred to the Emergency Procurement Service—same personnel, generally speaking—several things that were not conducive to good business in the judgment, at least, of the chairman of the committee.

First, perhaps, was that the stockpile created through acquisition of minerals by EPS, the Defense Materials Procurement Agency, ECA, MSA, and FOA—I still intend to introduce my bill to make it a penitentiary offense to refer to any agency by its initials—can be manipulated to break a market in the United States through an Executive order. The executive orders authorizing transfers from the stockpile have been made a part of the record.

Also, the records and testimony showed that we had given $200 million to England alone to purchase copper, zinc, and lead. The lead and zinc acquired by England with this money, was used to break the lead and zinc markets in this country early this year.

So we think there is some room for improvement. We think that the people of this country are entitled to know these things. They are entitled to know how their domestic industry was treated.

One statement I would like to reserve until later in the hearing, but I know you are axious to get away—you have many things to do before you start on your other trip—is this, for 20 years a bill of goods has been sold to the people of the United States of America that we must secure these materials from the sweatshop-labor countries so that the consumers may benefit. The testimony was very clear. We have probably 150 contracts for foreign minerals and materials. It developed that 77 percent of the material in the stockpile, has been purchased from foreign sources. In no event was there ever a foreign contract price brought to my attention which was lower than the domestic price. I think I can say it was generally above. The foreign producers use their low-cost labor and take what the traffic will bear here. So the consumers do not benefit.

I am certain, Mr. Secretary you would not approve of such an arrangement and when you come back before the committee, I know you will be ready then to go into more detail at that time.

Secretary McKay. Senator, I believe part of that was brought about by the time after Korea started in June of 1950. They went out in desperation to get some contracts for material and some of these contracts were written on the then market price. They took a contract to buy so much at a certain price. The price went down and they are still buying at the higher producer prices than domestic producers are getting. ODM has changed that procedure. I sit in on ODM meetings, and I know the policy has been changed so that in the future any contracts they make will be at the market price rather than a floor under it.

Senator Malone. The point I make is that I am not objecting to making contracts, but if you make contracts for foreign materials at the domestic market price, the argument that the consumer benefits is killed forever; is it not?

Secretary McKay. That is right.

Senator Malone. Then the fact that we did not have a going concern mining industry producing these so-called strategic minerals and materials made it necessary to make these foreign contracts during a war.

Secretary McKay. That is right.

Senator Malone. Then you would not agree that the best stockpile this country can acquire is a going concern mining industry?

Secretary McKay. Yes; it is very essential that the mining industry be sound and strong, and financially able to carry on.

Senator Malone. It also developed during these hearings that many of our domestic mines are closing down now because of the influx of lead, zinc, and other metals into the United States through dumping by foreign countries, the lead and zinc is running out of their ears. Many of these mines will never open again except through terrific additional expense, because of flooding and the mining methods employed when prices decrease. For example, in mining as the price goes down, as it has for zinc, lead, tungsten, mercury, and others, in order to keep the mine open the higher-grade ore is selected and sent to the mill and a tremendous amount of lower-grade ore, which would have been taken out if the price were higher, is left in the mine. That is never recovered because it is too expensive to go back and get it. The mines that are flooded will never be reopened. So it is lost forever to the people of the United States.

I would merely say to you, Mr. Secretary, that the evidence up to date shows that the domestic mining industry is in a very unhappy state. The policy of past administrations has been to develop foreign sources, and to shut down the domestic mining industry. You are familiar with that.

Secretary McKay. That was before my time. Since I have sat on ODM it certainly has not been the policy, Senator.

Senator Malone. When did you start?

Secretary McKay. When I came here. Of course, there was a new organization, and very few people on there that had any experience. George Humphrey, of course, knows the mining business, and he is a member. I believe they are correcting that situation.

Senator MALONE. It would be your policy, then, to try to establish a going concern mining industry in the United States of America.

Secretary MCKAY. Yes. That is very essential. As a matter of fact, many people overlook the mining business as such. They look upon it as a small business. It is really a tremendous business. It is essential to our industrial America, both the mining of minerals and coal. Of course, all the energy things, whether it be natural gas, hydro, coal, or oil, or atomic energy, if and when it is available, those things are drastically important to this country. None of these things we have to mine whether they are oil, lead, or zinc, are any good in the ground. Somebody has to get them out. You have to have a going concern.

Senator MALONE. You are aware, Mr. Secretary, that the fallacy in the idea of saving our own minerals in peacetime and securing them from some other source is that it requires 3 to 5 years to prospect and open a mine after you find the mineral. What you are really doing when you prospect and open a mine during a war is preparing for the next war instead of the current one.

So I am glad to hear you say that the mining industry is tremendously important to the economic structure of this country.

Secretary MCKAY. That is right.

Senator MALONE. Then it is doubly important to have these materials available through a going concern mining industry in the United States and adjacent countries when a war begins. If we are dependent upon nations far removed across oceans where it would be impossible to keep the lines of transportation open, it is a national defense problem, too, is it not?

Secretary MCKAY. That is right.

Senator MALONE. I am certainly glad, Mr. Secretary, that you and Mr. Humphrey and others are on this board now so that the economic structure of this country is now taken into consideration.

Secretary MCKAY. Yes, sir.

Senator MALONE. You do not consider it necessary to become dependent on foreign countries for the materials without which we cannot fight?

Secretary MCKAY. We do not want to become dependent on them, but in times of emergency we have to get some outside help from some of these countries for the materials that we are short of.

Senator MALONE. The testimony so far shows conclusively that your policies, if carried out, will result in our become self-sufficient in the United States, and in the Western Hemisphere, in many of these materials.

Secretary MCKAY. Yes, that is very important.

Senator MALONE. Would it be your policy to emphasize the importance of dealing with nations adjacent to us in the Western Hemisphere.

Secretary MCKAY. Yes. PAD has done the same thing on oil as you know in Venezuela. And there are opportunities in the Western Hemisphere to much better advantage in a war on some of these other minerals.

Senator MALONE. Many believe that the Western Hemisphere can be made self-sufficient in the production of strategic and critical minerals and materials which are necessary in time of war. if a 1-, 2-, 3-, or even a 5-year program is developed in the Western Hemisphere.

That would not interfere with the peacetime trade with all the nations of the world on a fair-trade basis, but the availibility of these materials at the start of a war would be assured. That is what you have in mind?

Secretary McKAY. Yes, sir.

Senator MALONE. We thank you very kindly, Mr. Secretary, for coming here, even though your plane was late.

Secretary McKAY. I am glad to come, sir. I say again, our Department is ready to assist you, but there are some people who know more about it than I do, especially Felix.

STATEMENT OF FELIX EDGAR WORMSER, ASSISTANT SECRETARY FOR MINERAL RESOURCES OF THE DEPARTMENT OF INTERIOR

Senator MALONE. Mr. Wormser, will you identify yourself for the record? I think the Secretary did a pretty fair job already.

Mr. WORMSER. Senator, my name is Felix Edgar Wormser. I am Assistant Secretary for Mineral Resources of the Department of Interior.

Senator MALONE. You have heard the Secretary's brief statement and testimony that he believes we should become as self-sufficient as possible in the United States and the Western Hemisphere in the materials without which we cannot fight a war, and how important he believes the industry is to the economic structure of this Nation. I am familiar, of course, with your record over the years, and I was very glad to see you appointed Assistant Secretary of the Interior.

Mr. WORMSER. Thank you, sir.

Senator MALONE. Would you like to make a general statement for the committee coverng the subject we are studying in detail?

Mr. WORMSER. I have no prepared statement, Senator; I am here to offer the services of the entire Department to facilitate the work of your committee. In fact, in the audience right now are quite a few of the Department's experts in the event that any of your questioning of me leads to requests for assistance on certain points with which I am not familiar.

By and large, the Department is very solicitous about the mining industry, and its desire is to further the orderly conservation and use of our still great mineral resources. I think the Secretary's statement along a similar vein is one which I wholeheartedly support.

I will be delighted to answer any questions you may have, Senator, if it is in my capacity to do so.

Senator MALONE. I would like to ask you the conditions under which the mining industry in the United States can be made a going concern industry, as the Secretary has testified it should be, and which it is not at the present time. In general, what is the matter with the policy that has been pursued in relation to the mining industry?

We are talking about the mining industry today because we have you here and you are in charge of the Bureau of Mines of the Department of the Interior. We have been working with many of your engineers. We intend to cover other industries, like the wool industry and other industries that are necessities in the national defense and the economic structure of this country.

Confining ourselves to the mining industry right now would you in your own way tell us what you think is wrong with the industry, why there is a hesitancy on the part of private capital to go into the industry, why it is necessary for Congress to pass special acts to encourage the mining of certain minerals, why it is necessary for the Government to participate in the financing of mines, and in general what would you do to establish a going concern private capital mining industry as we had in the past?

Mr. WORMSER. I think that is a broad order.

Senator MALONE. It is. It is the order that the committee has.

Mr. WORMSER. I think you have to break it down into its component parts. In other words, as I see it, every one of these minerals that are produced in this country has an entirely different situation. The situation in coal is different from what it is in oil, and from natural gas. The situation in lead and zinc is different from what it is in copper. The situation in fertilizer minerals is something else. I do not think you can state categorically that a certain approach will answer the problems that every one of these minerals industries have. That is my particular difficulty in giving you a direct answer to the question which you posed.

Senator MALONE. Would you then state the conditions under which you think the mining industry could be revived?

Mr. WORMSER. I think the best thing for the mining industry and it would apply to every one of them, is a good price for their product. That applies to coal, oil, copper, and lead. When you do not have a good market for your product, the industry becomes depressed.

Senator MALONE. What is preventing the mining industry from getting a good price?

Mr. WORMSER. There again if you have the ordinary law of supply and demand operating, it is generally an overproduction or underconsumption.

Senator MALONE. Let us get this straightened out. Do you have in mind a law of supply and demand for American producers, or are you referring to the world supply and demand?

Mr. WORMSER. I think I see what is going through your mind, Senator. There has been great interference with the law of supply and demand internationally, and I might also say in our own land. Coming to the second part first, our interference was the recent one, the Korean incident that began, and we imposed a ceiling on all mineral and metal products. That is a direct interference with the free market. It is of interest, Senator, to know that during that period, I think you will recall, that lead, zinc, and copper were imported into the United States, and consumers paid very fancy prices, far higher than ceiling prices, for these metals. Our miners were not allowed to export these products, and they were not allowed to get higher than ceiling prices. That is quite a substantial interference with the free-market economy.

Abroad we have had interference along the lines of government buying and selling of metals and minerals, which is certainly not a free-market economy.

Senator MALONE. You mean the buying and selling of foreign governments.

Mr. WORMSER. Yes; that is right.

Senator MALONE. Would you give us a little more detail for the benefit of the record?

Mr. WORMSER. I have in mind particularly the action of the British Government in buying lead and zinc, having the monopoly of buying and selling lead and zinc. They disposed of lead eventually with disastrous consequences on the market over here.

Senator MALONE. Would you be referring to the purchase of lead and zinc and copper with American taxpayers' money that the chairman referred to a while ago?

Mr. WORMSER. The source of their funds—presumably it all came from a central agency, but whether it was a part given by us or acquired through the ordinary function of the Government, I think is anybody's guess. It depends on how you consider it, Senator.

What I am trying to say is whether that money was deliberately given to a foreign government to use for that purpose——

Senator MALONE. I doubt that. What do you think of the procedure by which we gave England $200 million to purchase these metals, and then England turns around and dumps these metals on our domestic market?

Mr. WORMSER. Senator, I think I have expressed my views before. I am convinced that a free-market economy is the best thing for the people of the United States. I do not like to see it disappear. I will also put it internationally as well as nationally.

Senator MALONE. When you talk about a free market internationally, do you mean you would like to see the materials produced through the low-cost labor in Africa, Burma, and China, and all the other countries shipped into this country? Do you believe in a free market to that extent? In other words, it would be in competition with our own market.

Mr. WORMSER. When we talk about a free market——

Senator MALONE. What do you mean by a free market?

Mr. WORMSER. I mean when the ordinary operations of the law of supply and demand have full play.

Senator MALONE. Are you talking about the United States or the Western Hemisphere or the world?

Mr. WORMSER. I think your question was directed to the local situation, Senator. I am referring to the local situation.

Senator MALONE. In other words, you are talking about a free market in the United States, and a policy by Congress so that free-market competition is limited to competition within the United States of America.

Mr. WORMSER. That is correct.

Senator MALONE. How would you do that?

Mr. WORMSER. How would I do what, sir?

Senator MALONE. How would you establish a free market in the United States?

Mr. WORMSER. In a free market you do not do any arranging. Everybody has a right to buy or sell as he prefers.

Senator MALONE. That is true.

Mr. WORMSER. There is no planning in a free market.

Senator MALONE. I am speaking now of the United States of America, and the free market there; is there any interference in that free market from elsewhere?

Mr. WORMSER. When you speak of the international market, yes, there are interferences.

Senator MALONE. How would you deal with the international market in order to maintain free market in the United States?

Mr. WORMSER. Sir, that is beyond the province of the Department of the Interior.

Senator MALONE. I am asking you. You are an expert and you are in the mining business.

Mr. WORMSER. I think about all you can do is to foster the idea of a free-market economy and hope other nations will follow along the same line of thinking, sir.

Senator MALONE. Do you mean a free-market economy? Let us compare the production of copper and zinc in the Western Hemisphere with production in Africa. Do you favor a free market with no regulations of imports at all?

Mr. WORMSER. I think I see what you are driving at. There you touch upon the tariff question. I would say there you have to appraise each case on its own merits.

Senator MALONE. You are talking about each metal.

Mr. WORMSER. Each metal, precisely, or each mineral, if you will.

Senator MALONE. Each mineral, that is probably correct. How would you do that? There are other ways besides the tariff.

Mr. WORMSER. I believe, sir, that is your function, the function of Congress.

Senator MALONE. Not at the present time it is not. I have to disagree with you. The 1934 Trade Agreements Act transferred that constitutional responsibility from the legislative branch to the executive branch, and you are in the executive branch. Do you not remember, that Congress has nothing to do with it now at all?

Mr. WORMSER. I believe that is true, sir, under the Reciprocal Trade Agreement Act.

Senator MALONE. They call it the reciprocal trade. The two words do not appear in the act. Some people call it the 1934 Trade Agreements Act. It is an executive responsibility now, is it not?

Mr. WORMSER. That is correct, sir.

Senator MALONE. I agree with you that when you and I memorized the Constitution of the United States, it was a legislative function. Article I, section 8 of the Constitution says, "Congress shall have the power to lay and collect taxes, duties, imposts, and excises," and then says, "to regulate commerce with foreign nations." In other words, the Constitution states that Congress is to regulate foreign trade, and to adjust the duties, imposts, and excises. I am sorry we do not have the 1934 Trade Agreements Act here, but we will make it a part of the record at this point.

(The 1934 Trade Agreements Act is as follows:)

AN ACT To amend the Tariff Act of 1930 (48 Stat. 943)

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Tariff Act of 1930 is amended by adding at the end of title III the following:

"PART III—PROMOTION OF FOREIGN TRADE

"SEC. 350. (a) For the purpose of expanding foreign markets for the products of the United States (as a means of assisting in the present emergency in restoring the American standard of living, in overcoming domestic unemployment

and the present economic depression, in increasing the purchasing power of the American public, and in establishing and maintaining a better relationship among various branches of American agriculture, industry, mining, and commerce) by regulating the admission of foreign goods into the United States in accordance with the characteristics and needs of various branches of American production so that foreign markets will be made available to those branches of American production which require and are capable of developing such outlets by affording corresponding market opportunities for foreign products in the United States, the President, whenever he finds as a fact that any existing duties or other import restrictions of the United States or any foreign country are unduly burdening and restricting the foreign trade of the United States and that the purpose above declared will be promoted by the means hereinafter specified, is authorized from time to time—

"(1) To enter into foreign trade agreements with foreign governments or instrumentalities thereof; and

"(2) To proclaim such modifications of existing duties and other import restrictions, or such additional import restrictions, or such continuance, and for such minimum periods, of existing customs or excise treatment of any article covered by foreign trade agreements, as are required or appropriate to carry out any foreign trade agreement that the President has entered into hereunder. No proclamation shall be made increasing or decreasing by more than 50 per centum any existing rate of duty or transferring any article between the dutiable and free lists. The proclaimed duties and other import restrictions shall apply to articles the growth, produce, or manufacture of all foreign countries, whether imported directly, or indirectly: *Provided*, That the President may suspend the application to articles the growth, produce, or manufacture of any country because of its discriminatory treatment of American commerce or because of other acts or policies which in his opinion tend to defeat the purposes set forth in this section; and the proclaimed duties and other import restrictions shall be in effect from and after such time as is specified in the proclamation. The President may at any time terminate any such proclamation in whole or in part.

"(b) Nothing in this section shall be construed to prevent the application, with respect to rates of duty established under this section pursuant to agreements with countries other than Cuba, of the provisions of the treaty of commercial reciprocity concluded between the United States and the Republic of Cuba on December 11, 1902, or to preclude giving effect to an exclusive agreement with Cuba concluded under this section, modifying the existing preferential customs treatment of any article the growth, produce, or manufacture of Cuba: *Provided*, That the duties payable on such an article shall in no case be increased or decreased by more than 50 per centum of the duties now payable thereon.

"(c) As used in this section, the term 'duties and other import restrictions' includes (1) rate and form of import duties and classification of articles, and (2) limitations, prohibitions, charges, and exactions other than duties, imposed on importation or imposed for the regulation of imports."

SEC. 2. (a) Subparagraph (d) of paragraph 369, the last sentence of paragraph 1402, and the provisos to paragraphs 371, 401, 1650, 1687, and 1803 (1) of the Tariff Act of 1930 are repealed. The provisions of sections 336 and 516 (b) of the Tariff Act of 1930 shall not apply to any article with respect to the importation of which into the United States a foreign trade agreement has been concluded pursuant to this Act, or to any provision of any such agreement. The third paragraph of section 311 of the Tariff Act of 1930 shall apply to any agreement concluded pursuant to this Act to the extent only that such agreement assures to the United States a rate of duty on wheat flour produced in the United States which is preferential in respect to the lowest rate of duty imposed by the country with which such agreement has been concluded on like flour produced in any other country; and upon the withdrawal of wheat flour from bonded manufacturing warehouses for exportation to the country with which such agreement has been concluded, there shall be levied, collected, and paid on the imported wheat used, a duty equal to the amount of such assured preference.

(b) Every foreign trade agreement concluded pursuant to this Act shall be subject to termination, upon due notice to the foreign government concerned, at the end of not more than three years from the date on which the agreement comes into force, and, if not then terminated, shall be subject to termination thereafter upon not more than six months' notice.

(c) The authority of the President to enter into foreign trade agreements under section 1 of this Act shall terminate on the expiration of three years from the date of the enactment of this Act.

SEC. 3. Nothing in this Act shall be construed to give any authority to cancel or reduce, in any manner, any of the indebtedness of any foreign country to the United States.

SEC. 4. Before any foreign trade agreement is concluded with any foreign government or instrumentality thereof under the provisions of this Act, reasonable public notice of the intention to negotiate an agreement with such government or instrumentality shall be given in order that any interested person may have an opportunity to present his views to the President, or to such agency as the President may designate, under such rules and regulations as the President may prescribe; and before concluding such agreement the President shall seek information and advice with respect thereto from the United States Tariff Commission, the Departments of State, Agriculture, and Commerce, and from such other sources as he may deem appropriate.

Senator MALONE. Congress passed the Trade Agreements Act in 1934, and thereby transferred these powers of Congress under section 8 of the Constitution to the Executive. Now I am asking you what you think can be done to create a going concern domestic mining industry, one in which private capital would be invested?

Mr. WORMSER. Again, sir, I must ask you to be a little more specific as to whether you are referring to coal, oil, copper, lead, zinc, mercury, tungsten, or manganese.

Senator MALONE. All the metals.

Mr. WORMSER. I am sorry, sir. It is a question that I cannot answer without having a specific example put before me.

Senator MALONE. Take your own case of lead and zinc. Whether you take mercury, tungsten, or anything else, I do not see why any difference in the policy would be necessary. I would like to know what you think can be done in lead and zinc.

Mr. WORMSER. You mean to attract more capital to the development and exploration of these mines, or do you refer to the going property?

Senator MALONE. A going concern domestic mining industry and a going concern mining industry in my book does not mean Government-operated.

Mr. WORMSER. Or mine either, sir.

Senator MALONE. I knew that. So without further ado, tell us what could be done to create a going concern mining industry in the lead and zinc field.

Mr. WORMSER. Our problem, Senator, is to get a higher price for these metals.

Senator MALONE. I know what your problem is. I asked you how you would do it.

Mr. WORMSER. You would have to assume all sorts of powers.

Senator MALONE. You have them. The Executive has the power. You can make contracts. You can change your agreements on tariffs and trade.

Mr. WORMSER. There are lots of things you can do. I tried to make some of them clear in a speech I made in Idaho a few months ago.

For example, you can subsidize. You can raise the tariff. You can change your stockpiling objectives. There are three things that can be done. You can impose quotas on imports coming into the United States in excessive quantities. Those are items—not all of them—but some of them would require legislative action.

Senator MALONE. We have had legislative action for 21 years. We extended it again this year under your administration and mine.

My bill, including tungsten, manganese, chromite, and other minerals, extended your authority to purchase these minerals for 2 years.

Mr. WORMSER. Sir, that is not the Department of Interior's province. That belongs to DMPA, and we have nothing to do with that.

Senator MALONE. It is an executive department.

Mr. WORMSER. We have a lot of executive departments.

Senator MALONE. You were recruited from the mining business, the lead and zinc industry. What would you do if you had a free hand? The administration has a free hand.

Mr. WORMSER. Again I would say are you referring specifically to lead and zinc?

Senator MALONE. On your request. Myself, I do not see any difference between many mineral industries and many agricultural industries, and production industries, like the machine tool, watches, and crockery industries. They are all in the same boat. But at your request, I have narrowed it down to lead and zinc. What would we do if you and I could sit down today and do something about it? You could do it if you were so authorized by the Executive, because it is the Executive's prerogative now.

Mr. WORMSER. Speaking for myself, and following your direct line of inquiry, assuming you and I had the authority and confining it again to the lead and zinc picture we are discussing, and being aware of the fact that the predicament of these industries is due to an excessive flood of imports, I would endeavor to stop the excessive flood of imports coming into the United States.

Senator MALONE. I think that is a good answer. In the approach to the problem, then, as I understand you, there are several approaches. Either you can pay a direct subsidy like you were doing to butter and importing it from Denmark and storing our own and eating the Danish butter. Or you could pay a subsidy like we pay in wool and store our wool, and buy the Australian wool with no restriction whatsoever of imports. We could do the same way with every industry, figure out what subsidy would be necessary above the market price with an entire setup just as the State Department has finally arrived at, and keep you in business.

The subsidy, however, would have to be renewed by either the Congress or the Executive each year or every 2 or 3 years. It would be continually subject to renewal, would it not?

Mr. WORMSER. Yes; and beyond that, Senator, I have always had misgivings about subsidies, because they invite Government control. I think it is inevitable that if you subsidize an industry, the Government is entitled to step in and have a lot to say about how the industry is run and I am averse to such Government control.

Senator MALONE. Was not it Mr. Ickes who fixed a lot of policies when he was Secretary of the Interior, and one of his famous sayings was that anything the Government finances it is entitled to control? I think that was a very matter-of-fact statement. Whether people like it or not, or whether Government officials like it or not, eventually if the Government finances an industry, it must control it.

Mr. WORMSER. I think it was the late Senator Borah that made the same statement many years ago.

Senator MALONE. Then you are not very much in favor of subsidies as such?

Mr. WORMSER. No, sir.

Senator MALONE. In the industry we are discussing now.

Mr. WORMSER. The only way out, as I tried to point in Idaho, if we are ultimately forced to that sort of answer, is to have a uniform subsidy regardless of the position of any producer and based upon the unit of production, whether it is pound of copper or pound of manganese, or whatever it happens to be.

Senator MALONE. I could not be certain without checking it, but I remember they put a tariff on wool and the President vetoed it, and then the Congress passed a subsidy. I think it is 45 cents for a pound of wool of a certain grade and a certain kind, and it does not make any difference where it comes from. That is what you mean?

Mr. WORMSER. In substance that is what I have reference to.

Senator MALONE. In other words, to compute a subsidy you would have to figure out how much you needed in addition to the world price. Providing we had free imports, which we practically do have today as we are competing with foreign labor paid 40 or 50 cents a day or $2 a day, you would compute the cents or dollars per unit which you needed to keep the mining industry alive in a particular mineral in addition to what you would call the world price.

Mr. WORMSER. That is correct.

Senator MALONE. In order for you to pay the $12, $15, or $20 a day, or whatever the going wage is, that subsidy would really mean the difference between the wage standard of living between here and abroad.

Mr. WORMSER. That would have a very important bearing on it.

Senator MALONE. You would have to figure out your subsidy so that it would make up the difference between the wage standard of living between here and abroad where your competition is located. You would maintain our wage standard of living if you would pay the difference between our wages and foreign wages by paying a direct subsidy of cents per pound on lead and zinc.

Mr. WORMSER. That is correct.

Senator MALONE. You do not care much about that principle, because as you say it results in——

Mr. WORMSER. Government control.

Senator MALONE. And every year you would be before Congress and some committee making your case to continue it.

Mr. WORMSER. Precisely.

Senator MALONE. Now, on the matter of quotas, how would that operate? I am concluding from your testimony that the only way you can stay in business is to somehow limit your imports or equalize the cost of your imports with the cost of your domestic production.

Mr. WORMSER. I think we also ought to make it clear we do need imports. Our domestic economy has grown to such vast proportions that we do need large amounts of these metals. There was a time when we were on an export basis, but that day is past because of the vast quantities we use, so we have to have certain tonnages, and that has been recognized in lead and zinc.

Senator MALONE. Does an equalization of the price, either through a tariff or subsidy, prevent imports, or does it just bring them in on the basis of domestic cost?

Mr. WORMSER. I suppose you might argue either way. You might feel that in one case all it would mean would be a raising of the domestic price, or it might mean a partial raising of the domestic

price and perhaps a slight impact on the foreign market, depending entirely on domestic competitive conditions and on external competition. It is quite conceivable you might have so much internal competition that a tariff would not be effective.

Senator MALONE. What do you mean, so much internal competition?

Mr. WORMSER. In an open market there have been times in the past, Senator, when we have had tariff protection on lead, for example, when there was so much competition internally in the United States that the price in the domestic market was exactly the same as abroad.

Senator MALONE. Do you think you are entitled to a support price here in the amount you might produce above the amount needed in the United States? You just testified that you needed imports; but if you brought the imports in on your basis of cost, your standard of living wages, are you not asking for a support price on zinc and lead against your domestic producers?

Mr. WORMSER. I am not asking for anything. I am merely exploring with you the various expeditnes available to the Government in an effort to correct the situation.

Senator MALONE. I am sorry I asked the question in the way I did. I should have asked: Do you believe that any domestic producer in the mineral industry should be entitled to be paid for his metal at a price above the domestic price brought about by domestic competition, assuming that quotas, import fees, or duties, would bring in imported materials at the domestic market price?

Mr. WORMSER. I think, Senator, about all you can do is to generalize on that hypothetical question.

Senator MALONE. I do not think it is a hypothetical question. Suppose you were producing all the zinc and lead needed in the United States today in the United States, you would not be asking for a price that would guarantee you a profit to produce above that amount, would you?

Mr. WORMSER. No; but, Senator, I think you objected to the term "hypothetical," but now you are saying assuming we can produce all the lead and zinc needed in the United States.

Senator MALONE. I did not mean it that way. I am just saying that you reached that point in the past at certain times. You did in mercury and tungsten during the war at one time.

Mr. WORMSER. I thought we were confining this to lead and zinc.

Senator MALONE. I am in order to comply with your request to suggest specific commodities. But the hypothetical question would go clear beyond that. I do not want to get beyond our own domestic production. That is to say, how are you going to create a going-concern mining industry as your Secretary testified he wanted to do? You would not have to come to Congress each year, just as you did this year, just as many industries did this year, and my own bill kept them alive for 2 more years, but only for 2 additional years, if you had a duty or impost or excise tax that brought these materials in on your basis of cost. You are not indicating now that you want an additional price here for your metal to keep your going-concern mining business in competition with other mining companies in the United States.

Mr. WORMSER. I do not know whether I got your question, Senator.

Senator MALONE. The question is simply this: We have a going concern mining industry or we would not be producing more than we

need. We never would produce more than we need if it was not a going concern. As I understood you, you might need some additional money per pound to keep all these domestic producers in business after we were producing more than the market could consume here. I had not gone beyond that. I had not thought beyond that. If you are competing with each other you are not going to produce any more than the market will absorb.

Mr. WORMSER. But, sir, we do have internal competition. We have always had it.

Senator MALONE. And you want it.

Mr. WORMSER. We naturally want it.

Senator MALONE. You do not want to pay them for overproducing the market at home.

Mr. WORMSER. Coming back to lead, when you consider the fact that we need about 1,200,000 tons of lead a year and we are mining 325,000 or 350,000 tons——

Senator MALONE. Have you mined more than that?

Mr. WORMSER. Perhaps 600,000 tons 20 years ago.

Senator MALONE. What cut you down?

Mr. WORMSER. To go into that, there are several factors that entered into that development, Senator. I would say a lower grade ore by and large. The exhaustion of existing mines and the failure to intensify exploration.

Senator MALONE. What prevents intensified exploration? The mines I know of that are shutting down are not running out of ore, but cannot afford to pay the high domestic wages.

Mr. WORMSER. That comes into the question of economic matters that bear on the mining industry, such as your tax picture, for one thing.

Senator MALONE. We would like to get into that a little bit later. Of course, the foreign production has no tax structure such as we have. What we are talking about is either subsidy or a duty that would rise above a tax structure or anything else, and make you competitive only with your own people who pay the same taxes and the same wages that you pay.

Mr. WORMSER. All right.

Senator MALONE. You say a subsidy would do it but you do not like subsidies. Do you like quotas?

Mr. WORMSER. I have no objection to the use of a quota if it served the purpose.

Senator MALONE. There again you have a bureau official determining when to make a quota effective, when to raise the quota or manipulate the amount of the quota, do you not?

Mr. WORMSER. You would have to have some bureaucratic supervision, of course.

Senator MALONE. Have you had any satisfactory experience with the judgment of bureaus as to the regulations of this price through any other system?

Mr. WORMSER. I do not get the thought there, Senator. What do you mean by any other system?

Senator MALONE. The thought is that we financed one nation to produce and buy zinc and lead and copper and it broke up your market for you right under the noses of our own bureaus. Do you

think you could do a better job of manipulating under some new kind of bureau?

Mr. WORMSER. I am opposed to manipulation. I am in favor of free markets.

Senator MALONE. You are in favor of a free market in the United States of America in competition with other American producers.

Mr. WORMSER. That is right.

Senator MALONE. Are you in favor of free competition with all other nations of the world, regardless of what they pay for wages and taxes?

Mr. WORMSER. I think that is where you would have to be very careful and very solicitous in protecting your own domestic industries from harm.

Senator MALONE. That is what I would like to know. What kind of a system is the executive department using in approaching this matter?

Mr. WORMSER. As you know, Senator, that is one of the deep problems which is receiving the serious attention of the administration currently.

Senator MALONE. I hope it is, but we are not dismissing it that easily. The reason I was asking you is that I have to ask the people who are in the business. I will have to ask the men who are still in it. I think you heard the testimony of Mr. Fletcher.

Mr. WORMSER. I was not there. You could not have procured a more expert witness.

Senator MALONE. We will make his testimony available to you.

Mr. WORMSER. I would like to see it.

Senator MALONE. He said some kind of regulated flexible duty is necessary. His speech has been reported in the news several times since our Seattle hearings where he testified before this committee. His testimony before this committee was very clear. He wanted a principle laid down of a duty which would equalize the differential in cost as to the wage standard of living here and abroad.

Mr. WORMSER. Did he say difference in cost?

Senator MALONE. I do not remember the exact words he used, but the tariff or import fee or duty would bring minerals in at your level of costs. I think you are familiar with the testimony of a lot of your own people before the Ways and Means Committee of the House on the Simpson bill. Is that not what they said there? They were going to set a price that they thought ought to be maintained which would be subject to raising and lowering in accordance with the commodity index.

Mr. WORMSER. On the fluctuating domestic price?

Senator MALONE. I think they mentioned 16 cents a pound.

Mr. WORMSER. That is what confused me, whether you were referring to price or costs.

Senator MALONE. How could you refer to one without the other? In other words, one is dependent on the other. If you had a regular tariff or import fee with no mention of a 16-cent price, then you would generally regulate that on the basis of fair trade and bring it in on your level of cost. You mentioned 16 cents, which they did, figuring they could operate with 16 cents under present conditions, and raise that 16 cents with the commodity price or lower it, including labor and commodities; the tariff or duty would make up that difference in

each case. It would be removed when the price was 16 cents and go on when it went below. That price of 16 cents would be raised or lowered in line with the commodity index fluctuation. Is that not about what they testified to?

Mr. WORMSER. I believe it is.

Senator MALONE. Then that is a tariff we are talking about. Whether you put it on directly or you assume a price and maintain that price, that would be a matter of procedure. You were in favor of the Simpson bill; were you not?

Mr. WORMSER. I never expressed myself. I stood behind the Secretary's statement before the Ways and Means Committee. As I recall it, he expressed a desire to go along with the President, requesting a period in which the whole foreign trade policy of the Government might be examined.

Senator MALONE. Then we will go back to the point that your statement here is that you must have subsidies which would make the difference between a profitable or losing mining venture here, and the price that you can get on the market, or you must have quotas which would stop imports or regulate the imports so that the price would be maintained on a profitable basis, or you must have a tariff or import fee or a duty that would do the same thing.

Mr. WORMSER. Precisely. Those are the alternatives.

Senator MALONE. You do not like subsidy.

Mr. WORMSER. I do not like subsidy.

Senator MALONE. And you do not care much about quotas.

Mr. WORMSER. I do not care much about quotas.

Senator MALONE. We will leave it like that. We have been talking about the industry in the United States. The committee must go further than that, according to its resolution, which says that the committee should determine the availability and accessibility of strategic and critical minerals, materials, and fuels, some of which have been manipulated out of existence in this country through foreign competition. Then we must talk about the areas we can defend, what lines of transportation we can keep open. It is generally considered we can keep the lines of transportation open in the Western Hemisphere.

Then do you believe that we should include Western Hemisphere countries in our contracts for stockpiling and in general to make ourselves self-sufficient in all of these minerals, materials, and fuels in the Western Hemisphere?

Mr. WORMSER. May I say, Senator—as I am sure you know—the Department has nothing to do with stockpiling and the consummation of these contracts to which you have reference.

Senator MALONE. Your Secretary is a member of the Board.

Mr. WORMSER. ODM.

Senator MALONE. And fixes the policy.

Mr. WORMSER. That is correct. My office has nothing to do with that.

Senator MALONE. Your office as such, but you are a mining expert. I think you agree with the objectives of the committee to have these minerals and materials available in time of war.

Mr. WORMSER. Definitely. It is highly important all of the strategic and critical materials are in ample supply in the event of war.

Senator MALONE. Have you ever considered the question and do you have any idea as to whether or not the Western Hemisphere can

be made self-sufficient in the production of lead and zinc for our own use?

Mr. WORMSER. In lead and zinc, I am sure it can. I think there is enough zinc in North America and South America, perhaps even more than our requirements.

Senator MALONE. At least you are convinced that we can very easily with a year or 2 or 3 years' program make ourselves self-sufficient in the Western Hemisphere in the production of lead and zinc.

Mr. WORMSER. I believe that to be so.

Senator MALONE. You are not familiar with any other minerals, particularly?

Mr. WORMSER. Only except in a broad way. I think you might extend that to copper. South America is an important producer. Possibly in a metal in which we are entirely deficient, tin.

Senator MALONE. Mercury.

Mr. WORMSER. That would have to come from Canada, Mexico, and the United States. I am thinking of the Northern and Southern Hemispheres which would add to our supply. I should not be surprised as to mercury, our resources would be ample. I think you can go right down the list and quickly ascertain whether there is a prospect of reaching that goal.

Senator MALONE. Manganese.

Mr. WORMSER. We have the Brazilian sources to draw upon. Some in Mexico, some in Canada. I would not want to give snap judgment, Senator, and answer that question without specifically looking at the figures. If you would like we can ask one of our experts, or perhaps you intend to go into that tomorrow with some of them.

Senator MALONE. I know you will be available to the committee, and we are counting on your help and cooperation which we know we have.

Mr. WORMSER. I am delighted to give it, sir.

Senator MALONE. To follow through to some definite conclusion, realizing that you never finish the job, I had a very interesting talk today with a Cabinet officer, one that pleased me greatly. I wholeheartedly subscribe to his statement that you cannot say what you did yesterday was a mistake because what you do today may not be like what you did yesterday.

What relation is there between primary production and the secondary or reclaimed production of lead in the United States?

Mr. WORMSER. Senator, that is a very interesting question, because our economy has grown very heavily dependent on secondary lead, not so much in zinc. Lead is an outstanding example perhaps because of the ease with which you can reclaim lead from old storage batteries and lead scrap. The lead scrap produced in the United States per year now is quite a bit greater than the amount of lead from the domestic mines. It is a very important source of supply.

Senator MALONE. What is the proportion in tons produced?

Mr. WORMSER. Just drawing on memory and requesting an opportunity to revise the figures, as I recall, it is something like 500,000, compared with 350,000, tons of mine production. It is substantially higher.

Senator MALONE. In other words, we produce between eight and nine hundred thousand tons of lead, both primary metal and reclaimed metal out of the 1,200,000 tons consumed in this country?

Mr. WORMSER. That is right. Perhaps it may not be that high this year.

Senator MALONE. It would vary according to the price and the incentive to reclaim?

Mr. WORMSER. Yes, sir.

Senator MALONE. Is not the amount of reclaimed lead produced related to the amount of primary lead produced? In other words, the production of reclaimed lead increases in proportion to production of primary lead. If the primary metal production was raised to 600,000 tons, as it was at one time——

Mr. WORMSER. In fact, it was over that at one time, perhaps 625,000 tons.

Senator MALONE. And probably there is no reason why it could not reach that amount again if the incentive was present. The incentive being the establishment of a long-range principle through subsidies, quotas, duties, or tariffs, just so a real long-range principle would be assured.

The only trouble is that subsidies or quotas can hardly be called a long-range program because they must be renewed ever so often.

Mr. WORMSER. That is right.

Senator MALONE. A long-range principle upon which private investors could depend is needed.

Mr. WORMSER. That would be very helpful.

Senator MALONE. I will come back to the other question. With your long experience in mining, how long does it take to thoroughly prospect a discovery, build a mill, and get in production, after you find an outcropping or a reasonable showing of lead and zinc?

Mr. WORMSER. I would say anywhere from a year to 5 years or even longer.

Senator MALONE. It would be a very exceptional discovery if you got into production within a year?

Mr. WORMSER. I am thinking of some of the intensive work during the Korean emergency and war where every effort is being spent.

Senator MALONE. Where the Government is loaning money.

Mr. WORMSER. Precisely.

Senator MALONE. I am talking now about a long-range principle, such as that we had for many years in tungsten. Many prospectors, hundreds of them without technical education, would take a little pan and with 3 or 4 pannings of a tungsten outcrop and the appearance of white crystal in the bottom of the pan, could tell you pretty closely the percentage run of tungsten, could they not?

Mr. WORMSER. That is right.

Senator MALONE. As long as that long-range principle was in effect, which happened to be an import duty, they had an idea of about how much it had to run to be profitable, did they not?

Mr. WORMSER. They could estimate that.

Senator MALONE. In other words, they used to say that if they could find half of 1 percent tungsten, they were in business, if it was in a volume so it could be mined with some profitable method. But that was based on that long-range principle laid down and not disturbed until the 1934 Trade Agreements Act came into effect.

Mr. WORMSER. That is correct.

Senator MALONE. It is the same act that pulled the rug out from under the zinc and lead industry, as far as duty is concerned.

Mr. WORMSER. That is correct.

Senator MALONE. Do you suppose that the State Department for the past 20 years was interested in a going-concern domestic mining industry when they slowly lowered the floors under the lead and zinc industries?

Mr. WORMSER. Obviously, sir, I cannot speak for the State Department.

Senator MALONE. Could you speak for yourself if you were doing the same thing? Would you have in mind a going concern domestic mining industry?

Mr. WORMSER. I would certainly want to protect the mining industry of the United States.

Senator MALONE. But if you were continually pulling the protection out from under it, you could not say you were trying to establish a going concern industry. That would not be your objective, would it?

Mr. WORMSER. Lowering the tariffs is certainly not protecting the mining industry, if that is what you mean.

Senator MALONE. I mean for 20 years we continually pulled the rug out from not only the mining industry but other industries. Now we are discussing lead and zinc.

Mr. WORMSER. I think in that connection it is unfortunate that when the act of 1934 was promulgated nobody could visualize, at least very many people in the world, World War II, and saw the terrific inflation that you had which affected all tariff structures, and particularly those like the tariff on lead and zinc, that were on a specific rate. Those commodities which were fortunate enough to have an ad valorem rate went through the period all right. But the commodities that had a specific rate had an entirely different situation when the tariff cut hit them. It is entirely different cutting an ad valorem 50 percent than a specific rate in a period of inflation.

Senator MALONE. What you are saying is that during the past 20 years, the value of the dollar decreased to about 35 or 40 cents. If the tariff or duty was a certain number of cents per pound or unit, and it remained static, with the inflation and the price fluctuating in accordance with the value of money, then the tariff was automatically lowered without changing it.

Mr. WORMSER. That in substance is what I have in mind.

Senator MALONE. And it is just about as effective. In other words, any fixed tariff was lowered probably 60 percent, even if it had not been manipulated.

Mr. WORMSER. That is right.

Senator MALONE. But when you cut the tariff exactly in two, as was done in lead and zinc, and you had the inflation, then you were really——

Mr. WORMSER. Compounding the difficulty.

Senator MALONE. You were compounding the difficulty. That is a very good expression, I think.

Mr. WORMSER. Yes.

Senator MALONE. I would ask you, Mr. Secretary, if you are familiar with the report called the Paley report.

Mr. WORMSER. Yes, sir.

Senator MALONE. Are you familiar with its recommendations generally?

Mr. WORMSER. Yes, sir.

Senator MALONE. Would you describe that report? That report was made prior to your present officials taking office. The committee is very interested in your opinion of it.

Mr. WORMSER. I think I have said publicly, Senator, that the Paley report has some very fine things in it. I think they made some very intelligent study of some of our resource problems. They deserve unstinted praise for it. I could not find myself able to go along with some of their fundamental recommendations or, if you will; some of their conclusions, because I found out subsequently what I considered were their conclusions were merely recommendations. In other words they were drawing fine distinctions between some of their observations.

Senator MALONE. For example?

Mr. WORMSER. I found, for example, myself in complete variance with their philosophy of encouraging international commodity agreements as one answer to the difficulties of the mining industry. I felt that the foreign commodity agreement which they recommended for the mining industry was completely unsuited to our purpose; namely, that was the International Wheat Agreement. So I could not find myself in a position to go along with that. Nor with the idea that we might establish international agreements with buffer stocks.

Senator MALONE. What do you mean by "buffer stocks"?

Mr. WORMSER. That is a device which is often suggested to accumulate a stockpile of a certain metal, say tin, and the stockpile will be drawn upon during times of stringency and would grow in times of plenty so theoretically it is presumed it would act as a stabilizing agency in the tin market.

Senator MALONE. Could that result in the same thing that happened to the zinc-lead industry in the manipulation of the market through international control with the cooperation of Government bureaus in the United States?

Mr. WORMSER. I do not know if I get you.

Senator MALONE. Manipulation of the market. In other words, your judgment as to how to regulate the world supply might be one thing. Mine might be another. Another bureau official might have another idea. So if in the judgment of the bureau official the price was too high for zinc and lead in the United States, and you had this international cartel, you could break the price.

Mr. WORMSER. You put your finger on the very objection I had to the function of these groups, that I do not think that power should be put in any international group.

Senator MALONE. You do not believe in international cartels?

Mr. WORMSER. I do not believe in international cartels.

Senator MALONE. Are you familiar with the proposals of the International Trade Organization? After the Senate had turned thumbs down on that organization in committee and apparently there was no chance for approval by the Senate, it was succeeded by the International Materials Conference, created by the State Department. Are you familiar with the International Materials Conference?

Mr. WORMSER. I am familiar with the International Materials Conference. I expressed myself publicly before I took office, as a matter of fact, as being quite critical of that conference. I felt that it was taking us in a direction that was certainly not consonant with our free-enterprise economy. I did not think that any international group

should be armed with the power to tell the American people how much copper, lead, or zinc, or any other material they should use.

Senator MALONE. They should consume or produce.

Mr. WORMSER. Either way.

Senator MALONE. Would you tell us for the benefit of the record how this International Trade Organization and International Materials Conference were presumed to operate?

Mr. WORMSER. The International Materials Conference was organized shortly after the Korean incident.

Senator MALONE. Is that how we refer to Korea now, "the incident"?

Mr. WORMSER. I will be glad to use whatever language you suggest.

Senator MALONE. I often wonder whether it was a police action or an incident or World War III.

Mr. WORMSER. I would like to know just how to classify it.

Senator MALONE. And whether it is ended now or not.

Mr. WORMSER. That is another factor involved.

The international group was organized right here in Washington.

Senator MALONE. By the State Department, was it not?

Mr. WORMSER. I believe the State Department dealing with these international activities.

Senator MALONE. To take the place of the proposed International Trade Organization, which, of course, was refused confirmation by Congress. That organization originated back in Geneva and Torquay, and other international conferences.

Mr. WORMSER. They all had an interrelationship.

Senator MALONE. They all meant to do the same thing. So when all this happened, the International Materials Conference was created by the State Department. The International Trade Organization, or its successor, the International Materials Conference, how were they presumed to operate?

Mr. WORMSER. As I understand it, the International Materials Conference split up into various commodity committees, having on each committee representatives from the countries having an interest in the supply problems, and they met periodically and decided how much of each metal or mineral the United States and the other participating countries were to be allocated. It was a voluntary operation. They depended upon the various countries involved to arrange for the actual consummation of their particular part of the agreement.

Senator MALONE. The International Trade Organization, if it had been approved by the Congress, and its successor, the International Materials Conference, were to operate on the theory that the representatives of member nations, some 54 or 58 nations in the International Trade Organization, and about 12 or more in the International Materials Conference, would meet often, and at least once each year, to decide how much production there would be in the world of a particular material, what the consumption would normally be, and decide how much each country would be allowed to produce and consume. Was that the method to be used by these international bodies?

Mr. WORMSER. I think their intention was directed largely to how much each country would be allocated. I think at that time there was a shortage, so they were not so much concerned with the actual production problems as they were with the actual use of the materials.

Senator MALONE. There has been no shortage of world production in peacetime as far as we know. There have been shortages in war.

Mr. WORMSER. Yes; that is right.

Senator MALONE. Was not the idea, which was conceived at Geneva, to determine who should produce these materials, when you come right down to it?

Mr. WORMSER. I am not so certain about that, sir. My interest in it was directed to the fact that they were using this arrangement to tell us in this country how much various scarce materials we were supposed to use.

Senator MALONE. At least, you did not and do not agree that any arrangement like the International Trade Organization or the International Materials Conference which would operate as a worldwide cartel system to fix the prices and the consumption of any materials is a good thing?

Mr. WORMSER. I am very much opposed to it. I am for a free market.

Senator MALONE. You are for a free market with free competition in our country with the protection of our standard of living.

Mr. WORMSER. That is essentially what I am talking about.

Senator MALONE. Wage standard of living.

Mr. WORMSER. Yes, sir.

Senator MALONE. I think that nails it down. In other words, we have a school of thought which favors free international competition and our participation in it regardless of the wages paid in any other country. To that you are opposed.

Mr. WORMSER. I have no quarrel with international competition.

Senator MALONE. I am talking now about free international competition with us as a part of it, with no subsidies, quotas, or tariffs. Are you in favor of that?

Mr. WORMSER. Again, Senator, it is not quite clear in my mind as to your distinction.

Senator MALONE. I will clear it for you. We gave several million dollars to companies in Morocco to produce lead and zinc. Are you in favor of that lead and zinc, produced by low wages, coming into this country in free competition with the production of lead and zinc in the United States?

Mr. WORMSER. I would not be in favor of that right now, but under the stress of an emergency of war, there might have been different reasons.

Senator MALONE. I am not talking about the emergency of war. We do not have a war now.

Mr. WORMSER. Right now I am not in favor of it, sir.

Senator MALONE. It may be that one of our troubles is that we have had a set of officials for 20 years, and maybe we have them now who think they can manipulate this thing in time of peace and war and have Executive orders running the whole business. Are you in favor of that?

Mr. WORMSER. I am not in favor of that.

Senator MALONE. I think that clears it up. There was a very enticing phrase used for all these manipulations once each year under the International Trade Organization and its successor, the International Materials Conference, at which times the amount of production and the amount of consumption for each nation would be computed. I believe this phrase was "Entitlements for Consumption."

Mr. WORMSER. Yes, sir.

Senator MALONE. Are you familiar with that phrase?

Mr. WORMSER. Yes, sir.

Senator MALONE. What does it mean?

Mr. WORMSER. I think that was an expression coined to express the viewpoint of the International Materials Conference, namely, that various participating countries were entitled to just so much copper, let us say, or so much nickel or whatever they happened to be allocated.

Senator MALONE. Regardless of whether they participated in the production, and regardless of whether they were important in the world economic structure——

Mr. WORMSER. And regardless perhaps whether they had money to pay for it.

Senator MALONE. They were entitled to so much consumption.

Mr. WORMSER. That is right.

Senator MALONE. Entitlements for consumption, I have been intrigued by that expression.

Mr. WORMSER. So was I, sir.

Senator MALONE. Did not that occur in the Paley report?

Mr. WORMSER. I do not believe it did. I think it was confined to the IMC.

Senator MALONE. Did this plan during one of our very important periods cause an artificial shortage of lead and zinc in this country?

Mr. WORMSER. It did not apply to lead. It never had a lead committee. But they did have a copper committee and, as I recall, it did cause a serious shortage in copper.

Senator MALONE. Did they have a zinc committee?

Mr. WORMSER. I believe they did have a zinc committee. It has gone out of business, and my memory is a little hazy.

Senator MALONE. This International Materials Conference is still in being. It may be active on the surface in only 1 or 2 minerals, but the organization is still there, and the personnel who created it are still there. That might be of interest to you.

Mr. WORMSER. Very much so.

Senator MALONE. We would have had them here before now, except that an important witness has been in Europe. We hope he will return soon.

Are you familiar in general with the Bell report?

Mr. WORMSER. Broadly speaking, sir, yes.

Senator MALONE. Is it along the same lines as the Paley report?

Mr. WORMSER. I think the Bell report dealt with the problem of foreign trade, whereas the Paley report was a mineral report, and I do not think, Senator, you could compare them directly.

Senator MALONE. Did they not both indicate that we must, in the language of one of the famous Secretaries of the Interior, "save our supply of minerals and purchase from foreign nations"? Did they not both leave that impression?

Mr. WORMSER. I think they did, sir, come to think of it.

Senator MALONE. They had one common interest. If you want to condense the five-volume Paley report to one page, you could just say we are running out of these materials, and have very few of them, and must purchase them from foreign nations. Wasn't that the Paley report indication all the way through?

Mr. WORMSER. Perhaps that would be a way to get it in 15 words or so.

Senator MALONE. They took five volumes to say the same thing.

Mr. WORMSER. They called attention to the growing scarcity of certain minerals and metals.

Senator MALONE. That brings up a very important point—the growing scarcity. Under the policy adopted for the last 20 years of continually encouraging inflation, which, according to your testimony, has lowered the effect of any duty——

Mr. WORMSER. Any specific duty.

Senator MALONE. And it was specific for most of the minerals. Through inflation the duty was lowered anywhere from 50 to 65 percent.

Mr. WORMSER. Considering the entire gamut of all the metals and minerals.

Senator MALONE. Take zinc and lead. If the inflation was 2 to 1, you just about cut the fixed duty in two.

Mr. WORMSER. That is correct, if you are looking at it that way.

Senator MALONE. I am starting that way. Then they did actually cut it in two.

Mr. WORMSER. It was 2⅛ basis on lead originally.

Senator MALONE. The State Department in one of their agreements lowered it 50 percent.

Mr. WORMSER. That is right.

Senator MALONE. Would you say that policy adopted for the last 20 years would slowly encourage the scarcity about which they complained?

Mr. WORMSER. It certainly did nothing to help it.

Senator MALONE. I should say you are in the business. I think you could go a little stronger than that one way or another. If you continually make it unprofitable to mine these minerals in this country, production in this country is bound to decrease. What is the price of zinc and lead now?

Mr. WORMSER. The price of lead is 13½, New York.

Senator MALONE. Zinc?

Mr. WORMSER. Zinc is 10 cents, East St. Louis.

Senator MALONE. Can you profitably continue your mining operations at those prices?

Mr. WORMSER. I am sure there are very few companies making any money on those prices.

Senator MALONE. I think all you have to do is watch the newspapers in the last 6 months and you will notice that the mines are slowly closing. The wet mines will not open. You agree with that?

Mr. WORMSER. Definitely.

Senator MALONE. Then if for 20 years, now for 21, we have a policy of making our own production unprofitable, would not it gradually emphasize and bring about the very shortage of the domestic production about which they complain?

Mr. WORMSER. There is no shortage currently, sir. There is no complaint currently of any shortage that I know. Perhaps what you are trying to develop, Senator, if I may be so bold as to help you out, is the fact that our production has gone down decisively in both lead and zinc.

Senator MALONE. I was not talking about international production.

Mr. WORMSER. I am talking about domestic production.

Senator MALONE. So I was all right with my question. Naturally you can have all the world production you want of the 74 materials, but I am asking you if the policy for the last 20 years has not been conducive to cutting domestic production?

Mr. WORMSER. I believe it has, sir.

Senator MALONE. You are not in the sheep business and nobody in his right mind would put $2 in the domestic sheep business at the present time, but the production of wool in this country has been cut in half just as in lead. There is no difference in the policy. But the policy of the administration for 20 years has been to encourage foreign production and to cut domestic production. That is, they may give lipservice to domestic production. The effect of what has been done to lead and zinc is the same as what they have done to wool. The elimination of any duty or tariff on wool and allowing cheap labor goods to come in had the effect of making the cost of wool $2.50 a sheep unit in Australia and $8.50 here. That may be compared to the importation of lead and zinc from 40-cents-a-day labor countries and our labor costs of $15 a day. If you have 20 years of that policy, will you not finally arrive at the result they predicted in the beginning, that we are short?

Mr. WORMSER. That is a logical assumption.

Senator MALONE. You agree with that assumption?

Mr. WORMSER. I agree with that.

Senator MALONE. You already testified that you are against using stockpiles, as you referred to it, as buffer stock. Under that method when it is the judgment of a bureau official or combination of bureau officials and the governments of foreign nations that the price of material should be lower, some of our stockpile would be released.

Mr. WORMSER. I am against that.

Senator MALONE. You knew that our own stockpile at the moment is susceptible to that manipulation?

Mr. WORMSER. I believe the law stipulates that it can only be utilized under an Executive order or congressional order.

Senator MALONE. Executive order.

Mr. WORMSER. Does not it stipulate under emergency conditons?

Senator MALONE. Who is to judge?

Mr. WORMSER. I think it is pretty well locked up according to the statutes.

Senator MALONE. The testimony did not show that. The President of the United States can write a letter tomorrow morning releasing any of the stockpile. It was testified before this committee that such a letter was written about tungsten. You are familiar with the fact that the Government in its stockpiling does not pay a tariff or import fee or duty. You understand that.

Mr. WORMSER. Yes.

Senator MALONE. On this tungsten a letter was written and the tungsten was transferred from the stockpile to private industry. Another Government official set a ceiling price of $65 a unit, and to sell it at that price they could not include the tariff. Therefore, the

Government paid the tariff and sold it to private industry without taking into account the cost of the tariff.

Mr. WORMSER. I am not familiar with that.

Senator MALONE. Do you agree with that sort of an operation?

Mr. WORMSER. I do not like it, sir.

Senator MALONE. I will read you a list of materials. I am unable to give you the amounts. Stockpile withdrawals and diversions; aluminum, copper, cryolite, lead, rutile, tungsten, zinc. Does that answer your question as to whether or not it can be done?

Mr. WORMSER. Were those withdrawals made while we were fighting Korea, or were they made in the last few days, or just when were they made? I do not know the circumstances.

Senator MALONE. They can be made by Executive order and the Congress has no control over such a withdrawal.

Mr. WORMSER. Under war conditions?

Senator MALONE. Under any conditions. In anything the Executive may call an emergency.

Mr. WORMSER. I do not consider myself legally competent to decide when and where the stockpile——

Senator MALONE. Under any condition that the President of the United States might consider an emergency, whatever the emergency may be. Then he writes a letter and the material can come out of the stockpile, and break the market.

Mr. WORMSER. That is the weakness of any efforts to stabilize the market through any means, whether it is military stock or buffer stock.

Senator MALONE. Is it not the fundamental weakness of any stockpile program left to the whim of an executive officer?

Mr. WORMSER. Precisely; the human equation and human judgment comes in there, with endeavors to usurp the functions of a free market, almost invariably unsuccessfully.

Senator MALONE. Mr. Secretary, we appreciate very much having you here. As you have been in office only 9 or 10 months I appreciate your reluctance to testify to anything which has not been determined to be the policy of the new administration. As you say, many of these problems are currently being studied.

Mr. WORMSER. They are being forged currently. It would be rather premature to make any declaration.

Senator MALONE. But you also appreciate the position of this committee which has been directed by the United States Senate to secure certain information.

Mr. WORMSER. Therefore we would like to give you every assistance possible from our Department.

Senator MALONE. I think you have today. We would like very much to have you and Secretary McKay appear before the committee again. Perhaps next month will be an appropriate time.

Mr. WORMSER. I shall be delighted to, because I think at that time we shall have more to offer.

Senator MALONE. We thank you very kindly.

Mr. WORMSER. Thank you, sir.

Senator MALONE. Tomorrow at 9:30 we will hear the experts in the various mineral fields from the Bureau of Mines. They have helped prepare the factual material for the committee. I hope you will all be here. If there is any reason why any of you could not be here or if it would be inconvenient—I am sure we cannot hear all of you in the morning—please get in touch with our counsel and we will be very happy to arrange a schedule to suit your convenience.

(Thereupon, at 4:35 p. m., a recess was taken until Wednesday, October 21, 1953, at 9:30 a. m.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

WEDNESDAY, OCTOBER 21, 1953

UNITED STATES SENATE, SUBCOMMITTEE ON
MINERALS, MATERIALS, AND FUEL ECONOMICS,
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to recess, at 9:30 a. m., in the committee room, 224 Senate Office Building, Washington, D. C., Senator George W. Malone, Nevada (chairman of the subcommittee) presiding.

Present: Senator George W. Malone, Nevada (chairman of the subcommittee).

Present also: Jerome S. Adlerman, counsel to the subcommittee; George B. Holderer, committee engineer.

Senator MALONE. The committee will be in order.

The committee appreciates very much the sacrifice in time that I know you are all making to be here, and that you have made prior to this time in the preparation of the charts and texts on the individual minerals and materials which already have been furnished the committee.

Mr. Tom Miller, will you come forward. Is Mr. Forbes here?

STATEMENT OF THOMAS H. MILLER, ASSISTANT DIRECTOR, BUREAU OF MINES, DEPARTMENT OF THE INTERIOR, WASHINGTON, D. C.

Mr. MILLER. Mr. Chairman, the Director is out of the city and will not be back until the end of the week.

Senator MALONE. You are the Assistant Director?

Mr. MILLER. I am the Assistant Director of the Bureau of Mines; yes, sir.

Senator MALONE. Will you express to the Director, Mr. Forbes, the committee's appreciation of the assistance and cooperation that we have had from the Bureau of Mines? I am now expressing that appreciation to you. We will try to hear from Mr. Forbes later at his convenience.

Our procedure, as you noticed yesterday, was to start at the top and go right down through your organization to the individuals who are actually doing the basic and detailed work for you. I knew that was your wish.

Mr. MILLER. That is correct. I am sure if the Director were here, he would repeat the statements that both the Secretary and Assistant

Secretary made yesterday, and I am sure he would want me to repeat them in his absence: That the full facilities of the Bureau of Mines are available to this committee to whatever extent you need them in order to get the information together that the committee needs.

Senator MALONE. You have already shown that cooperation, which has been very much appreciated.

Now, Mr. Miller, if you have any general statement you would like to make about the work of the Bureau, the committee will appreciate receiving it at this time. Following the testimony of the individual engineers who are actually working under you and have done the detailed work, perhaps you would like to make a summation—either you or Mr. Forbes, or both of you.

Mr. MILLER. I would like to do that, if you wish, Mr. Chairman.

Senator MALONE. You may make any statement you desire to make.

Mr. MILLER. I have no general statement to make at this time. As you know, there have been a number of consultations between the staff of this committee and the Bureau in preparing the types of information that were needed. Much of that falls in the minerals field under the general supervision of Mr. Zinner. Mr. Zinner is here this morning with most of his branch chiefs, and they are prepared to introduce the material which has been prepared for this committee. If it is agreeable with you, we are prepared to start our presentation at the convenience of the committee.

Senator MALONE. Mr. Miller, I personally have been acquainted with your work for a considerable period of time. It is hardly necessary to say that in my opinion the Bureau of Mines has done the outstanding work in this field which has been done by any Government department. There have, of course, been times when there have been special committees and special commissions appointed to do a particular job, but your department was the source of the information.

Mr. MILLER. We certainly appreciated your support, Senator. Our interest in this field is, of course, very extensive. Our limitations are not in our interest but in our ability to secure sufficient funds to do more. We can do more if we had more money. It is the usual situation that Government agencies find themselves in, in not being able to do all of the things they would like to do, particularly in the analysis of the basic data which we do collect.

Senator MALONE. If I might say at this time, Mr. Miller—and I am counting on a couple of your outstanding men to give us the benefit of their experience and advice—Mr. Oliver Ralston and Mr. Elmer Person—you were here yesterday and heard the instructions that the Senate gave this committee. The committee is to determine the accessibility and availability of the strategic and critical minerals, materials, and fuels to the United States in time of war, for the expanding economy, and for its security.

Based on long experience with your Bureau, it is my opinion that the new material called titanium was a result of the activities of your Bureau. In our Henderson hearing we heard three of your people who are authorities in the field. Apparently considerable work remains to be done on that material, but as a result of your work there is new tremendous interest in titanium. There may be a hearing set on the west coast to hear what the airplane manufacturers actually believe the demand for titanium would be if it were available.

Mr. MILLER. Yes, sir.

Senator MALONE. We heard testimony from the head of Wright-Patterson Field at Dayton, Ohio, that instead of the present production of the 7 or 8 tons of titanium per day, amounting to 2,500 or 2,600 tons per year, if we had available the amount of material which could be used by the designers of military and commercial aircraft, from 100,000 to 150,000 tons per year would probably be used.

Mr. MILLER. It is an astonishing figure.

Senator MALONE. I remember when your man, Dr. John Koster, at the Reno Laboratory of the Bureau of Mines some years ago, in the early thirties I believe, worked out and perfected the method of electrolytic manganese. He was working with other branches of your Bureau.

These results have all marked progress. In this committee, I have in mind following through to a conclusion as to how self-sufficient the United States might become in the production of strategic and critical minerals and materials and fuels with proper incentive and as sound governmental policy. We also intend to ascertain the self-sufficiency of the Western Hemisphere, because the further we go to obtain these materials the more difficult it will be to keep the sea lanes open.

So it may be that a 1-, 2-, or 3-year program of research and exploration might be necessary to determine the self-sufficiency of the Western Hemisphere for some of these more strategic materials. If the hearings determine that such a program is necessary, I think the committee will mention it in their report.

Now, Mr. Zinner, will you identify yourself for the record.

STATEMENT OF PAUL ZINNER, CHIEF, MINERALS DIVISION, BUREAU OF MINES, DEPARTMENT OF THE INTERIOR, WASHINGTON, D. C.

Mr. ZINNER. Mr. Chairman, my name is Paul Zinner. I am Chief of the Minerals Division of the Bureau of Mines.

I would like to introduce at this time two charts. The first appeared originally on page 179 of the Minerals Position paper, and the second appeared in the same paper on page 183.[1] These have been modified and brought up to date in two ways. (See p. 45.)

Senator MALONE. First, I would like to ask you, Mr. Zinner, whether you are prepared this morning, after you make a general statement, to call the engineers in each particular field and area of minerals to complete the factual record of the production and acquisition of each of these materials either produced in the United States or brought into the United States from the Western Hemisphere, or from other foreign nations.

Mr. ZINNER. That is correct. With more than 70 commodities under consideration here, it is virtually impossible for one man to retain all of the factual data. I must apologize for having so many people involved in this presentation, but this group represents the best concentration of knowledge that we can make, in the fuels and metals categories.

[1] Investigation of Natural Resources, hearings before a subcommittee of the Committee on Public Lands, U. S. Senate, 80th Cong., May 15, 16, and 20, 1947.

With regard to these charts, they have been expanded to describe three areas, the first being the United States; the second representing the United States, Canada, and Mexico; and the third the Western Hemisphere. There have been a number of commodities added to the list that appeared in the original paper and some other modifications.

I would like to explain the second chart. (See p. 45.)

Senator MALONE. Which chart do you call the second?

Mr. ZINNER. The one describing our mineral position—actual, impending, and potential.

Senator MALONE. No. 1 is the bar chart?

Mr. ZINNER. That is right. On No. 2, you will notice that in each of the three areas we have commodities distributed in two columns. One represents the actual or impending position, and one the potential. If you will refer to the Western Hemisphere under the potential column, you will notice that, disregarding economics and a number of other conditions, and assuming improvements in technology and the validity of inferred resources, this chart indicates that the only commodity that we would be completely dependent upon from foreign sources—foreign to the Western Hemisphere—is industrial diamonds.

I would like to caution that this is subject to a number of interpretations, and that we can justify this chart only by a detailed explanation of each of the commodities concerned. The word "commercial" appearing here in quotations presented the same difficulty that it did in your original Mineral Position paper. The definition of a "commercial" reserve, in one instance, might not apply necessarily to another commodity. I think the problem will be brought out as we proceed through these commodity discussions.

Senator MALONE. Let me ask you right there, Mr. Zinner, is not the word "commercial" used rather loosely and a relative term, meaning this, that the use of the word "commercial" would be appropriate in a discussion of competition within the United States, where concerns competing with each other, pay the same wages and are confronted with the same standard of living?

In other words, if we had zinc from mines in Utah and Colorado, and zinc from outside the United States imported and sold on the basis of our standard of living, then there would be direct competition between the mines involved. Each one of these mines would be considered commercial only if it could be profitably operated by paying the same wages, costs of materials, industrial insurance, unemployment insurance, social security, and other employees' benefits enjoyed by workmen in this country. That would be one definition of commercial.

Another definition of "commercial" would be when we continue the direct competition from the lower wage countries to the United States. In that case, the United States mine would have to pay $12 or $15 a day for labor, plus industrial insurance, unemployment insurance, and social security, and the American costs of material, and compete with a mine in Morocco, where wages are very low, practically no such protection to the workers as industrial insurance, unemployment insurance, or social security. Then "commercial" takes on another meaning, does it not?

Mr. ZINNER. Exactly. That is the very difficulty we have, and the reason why the word "commercial" appears in quotations on both of these sheets.

Probably the outstanding example that we have is the case of iron ore. These sheets contemplate iron ore on the basis of past practice in the iron-mining industry, and their use of the word "commercial." It does not anticipate the iron formations which are, in fact, real resources in this country like the low-grade taconites and other iron-formation materials, even though there will be something like 1 million tons of marketable product derived from such sources this year. That illustrates the problem we encounter in trying to put resource data in tabular form. That is why I urge there be careful interpretation of these charts.

Senator MALONE. I think in the long run you would agree with this statement, that the policies adopted by Congress will eventually help you in a definition of the term "commercial." In other words, our present practice is to bring in the foreign materials with practically no equalization of the disparity between our wage standard as compared to foreign wages. Labor costs in Morocco are about 11 cents an hour, and $1.80 and $2 and $2.25 per hour in this country. While it might take 4 or 5 Arabs to make up for 1 good Irishman in this country, you could pay the Moroccans and have $6 or $7 left. You are confused by the term "commercial" because we are confused in our national policy; is that right?

Mr. ZINNER. I think it is correct to state that legislative action and administrative action that bears directly on the mineral industry will certainly have an effect on how we use the term "commercial."

Senator MALONE. That is true, and you are going to be bound by the policies adopted, which we hope will be made within the next 6 or 7 months. As a matter of fact, for 20 years has it not been a little hard to pin down a commercial cost?

Mr. ZINNER. I think that is absolutely true. Again, in contemplating this chart, we were concerned with the word "commercial" in relation to lead and zinc resources. It was difficult to decide if we should make our cutoff on the basis of properties that can be operated today under present prices, or (2) whether this should include blocked-out ore that was minable at one time and was not being mined at the moment, or (3) whether it should include ore that had never been mined, but was definitely measured or indicated.

For the purpose of this presentation the estimated resources include all of those categories in the case of lead and zinc. The same criteria have not been used in tabulating some of the other commodities.

Senator MALONE. As a matter of fact, then, what you are trying to do in chart No. 1 is to show us what the immediate situation happens to be?

Mr. ZINNER. This is based entirely on our present-day concept.

Senator MALONE. In other words, in our manufacture and production of titanium, we are getting the rutile ore from Australia when as a matter of fact, engineers are fully aware of the ample supply of the ilmenite ore in the United States and Canada which would take the place of foreign rutile.

Mr. ZINNER. That is exactly true. That is the type of interpretation we have used in this second chart.

Senator MALONE. In other words, the second chart is an interpretation of the first to show what you really believe about the situation.

Mr. ZINNER. That is right. In the second chart we anticipate eventual broad improvements in technology. We have I think good

reason to believe that. We have, for example, the case of quartz crystal, where technology has moved a commodity out of the critical category entirely into a satisfactory position. We have a number of other instances like that. Similarly, we have faith that technology will, in many instances, permit the employment of low-grade reserves that have never been mined or cannot conceivably be mined under present conditions.

Senator MALONE. We know what those conditions are. They are in direct competition with the low-wage labor of the world.

Mr. ZINNER. That is right.

Senator MALONE. And this has slowly been brought about during the last 20 years. We are not discussing now whether that is a proper thing or not. Maybe Congress will decide it is proper and should be continued. Maybe it will decide it is not.

Not considering whether it is right or wrong, the United States producers have been in almost direct competition with the foreign low-wage-area producers, is that true?

Mr. ZINNER. I think in many of the metals that is absolutely true.

Senator MALONE. Chart No. 2 is based upon the combined experience and technical knowledge of the Bureau of Mines of what could be done in this country and the Western Hemisphere. I say again that while there have been over the last 20 years several very learned reports, I know of no report with any basic information on minerals—and these materials that are generally classed in the mineral field—which did not contain basic information furnished by your organization. This information was then interpreted to a large degree—and we will let the evidence decide when we bring these organizations in—backwards and a lot of the information and advice they received from your Department was ignored.

Mr. ZINNER. I think that is true, Mr. Chairman. The facts that we will present here today have been available to most or all people who have been writing reports of one kind or another.

Senator MALONE. But perhaps they ignored this basic data in drawing their conclusions. In other words, there has been a political factor involved in the conclusions made in these reports. Would you not say that is a conservative statement?

Mr. ZINNER. I would not say always.

Senator MALONE. I did not mean always. But in the case of these scarce materials there has been a political factor, and that is, we should buy certain materials or a certain amount of money should be spent in certain countries for political purposes. That factor has been applied to the facts furnished by your Department which made the results and conclusions have little relation to the facts you supplied.

Mr. ZINNER. I think that is possible.

Senator MALONE. Do you not think it is true?

Mr. ZINNER. I think in many cases it probably is. I just would not know.

Senator MALONE. Now, refer to your last column on your table No. 2. The reason I am skipping to that table is because the instructions to our committee are to determine the availability of these materials to the United States in wartime. We will determine through experienced military strategists before we finish the transportation lines which can be kept open in wartime. But I would say to you that the advice the committee is getting unofficially in that the

transportation lines from the Western Hempishere to this country can be kept open in time of war if we are properly prepared. However, there is real doubt that we can keep any interocean transportation lines open in case of an all out war.

Let us discuss the column in chart 2, labeled Western Hemisphere mineral position, actual and impending, and based on present technologic and economic conditions and commercial reserves. That is what you would consider a rather conservative viewpoint, I presume.

Mr. ZINNER. That is right.

Senator MALONE. That is a rather conservative estimate.

Mr. ZINNER. That is right.

Senator MALONE. In that column, first without going into the list—it is a rather complete list all the way from anthracite and bituminous coal, aluminum ores, beryllium, all the way down to titanium, zirconium, zinc, nitrates, phosphate rock, sulfur—we have little reason to worry about the availability of all these materials in the Western Hemisphere. As a matter of fact, from your list we can become self-sufficient if we have an effective program.

Mr. ZINNER. That is right. The program is most important, too. In that same column we have advanced technologic development on some commodities but it should not be inferred that this has been developed into a going concern. Some of this technology has not been proven or been reflected into production as yet. We know the technology and the resources, but we have no industry.

Senator MALONE. In other words, let us see if your idea corresponds to the chairman's views. The best assurance of an ample supply of such minerals and materials in time of war is a going-concern industry.

Mr. ZINNER. That is the idea.

Senator MALONE. And the opinion of the Mining Bureau and its officials is that if proper attention is paid to the situation a going-concern industry can establish virtual self-sufficiency for a long time.

Mr. ZINNER. That is correct.

Senator MALONE. Now, we go to the list marked as list B. Right at that point, I am going to ask the reporter to copy the entire list under item A in chart 2.

(The list is as follows:)

WESTERN HEMISPHERE

ACTUAL OR IMPENDING

(Based on present technologic and economic conditions and on "commercial" reserves)

A. Virtual self-sufficiency assured for a long time

Anthracite, bituminous coal and lignite, helium, natural gas, petroleum, aluminum ores, antimony, arsenic, beryllium, bismuth, cadmium, copper, gallium, gold, indium, iron ore, lead, magnesium, molybdenum, nickel, platinum metals, rare earth metals, selenium, silver, tellurium, thallium, titanium (ilmenite), zinc, zirconium, barite, boron minerals, bromine, lithium (spodumene), nitrates, phosphate rock, potash, quartz crystal (radio grade), salt, steatite talc (for grinding), sulfur.

Senator MALONE. B describes commodities where there is complete or virtual dependence on foreign sources. I will ask the reporter to insert that at this point.

(The list is as follows:)

WESTERN HEMISPHERE

ACTUAL AND IMPENDING

B. Complete or virtual dependence on foreign sources

1. Small or remote expectation of improving position through discovery: Chromite, corundum, diamonds (industrial), graphite (strategic), jewel bearings, kyanite (strategic), steatite talc (block).

3. Good expectation of improving position through synthesis: Corundum, kyanite (strategic), steatite talc (block), diamonds (industrial).

Senator MALONE. That is a complete list of minerals and materials that we are now in part or in whole dependent on foreign sources; that is, sources outside of the Western Hemisphere.

Mr. ZINNER. That is correct.

Senator MALONE. Now, under No. 3, still under B, "Good expectation of improving position through synthesis."

You mean by that synthetic material that will do the work of the minerals and materials which are scarce?

Mr. ZINNER. Exactly. It might be one of two things. It might actually be synthesis of this commodity resulting from putting the exact elements of the natural substance, or it may be a group of elements assembled in a product that has similar properties to the natural substance.

Senator MALONE. In other words, a substitute.

Mr. ZINNER. Either one, that is right.

Senator MALONE. It might be a synthesis or it might be a substitute.

Mr. ZINNER. That is correct.

Senator MALONE. I will ask that No. 3 under B be copied into the record.

Under C, "Partial dependence on foreign sources, actual or impending; 1. Good expectation of improving position through discovery," that includes cobalt, columbium-tantalum, manganese, mercury, tin, titanium through rutile, and, of course, through ilmenite ore, tungsten, asbestos, fluorspar, iodine, mica, and other materials. I will ask the reporter to include this list at this point in the record.

(The list is as follows:)

WESTERN HEMISPHERE

ACTUAL AND IMPENDING

C. Partial dependence on foreign sources, actual or impending

1. Good expectation of improving position through discovery: Cesium-rubidium, cobalt, columbium-tantalum, germanium, manganese, mercury, tin, titanium (rutile), tungsten, asbestos, fluorspar, iodine, mica (strategic), strontium minerals.

Mr. ZINNER. You brought up ilmenite. I would like to point out that it is listed here under A. "Virtual self-sufficiency." This is a rather important division because, as you know, the titanium processes at the present time are geared largely to rutile.

Senator MALONE. But they can very easily use the ilmenite ore.

Mr. ZINNER. That is a subject of technologic research at the present time.

Senator MALONE. It was testified I think at our hearing in Henderson that the ilmenite ore could be substituted without any great hardship if they were assured of the supply.

Mr. ZINNER. Of course, there is an added cost in using ilmenite over rutile under present processes. We have faith that improvements in

existing processes or development of new processes will permit complete substitution.

Senator MALONE. In your last column No. 6, the "Western Hemisphere, potential, if technologic and economic changes permit use of known submargin resources," there is shown a most complete list. The same list under A, "Virtual self-sufficiency" under the "Potential" heading, is simply our enlarged list A, "Actual and impending"; is that true?

Mr. ZINNER. Parts of B and C in the "Actual and impending" list have moved over now to the "Potential" list.

Senator MALONE. Yes. Now, with respect to the list A, "Virtual self-sufficiency" under "Potential" heading, if a proper program of production is adopted and under proper principles, you have little doubt that the Western Hemisphere would be virtually self-sufficient in production of minerals listed there.

Mr. ZINNER. With the exception of the commodities that are under B and C in the "Potential" column.

Senator MALONE. Yes. I am moving on to that. I will ask the reporter at this time to include under "Western Hemisphere potential" under A, "Virtual self-sufficiency," the complete list.

(The list is as follows:)

WESTERN HEMISPHERE

POTENTIAL

(If technologic and economic changes permit use of known submarginal resources)

A. Virtual self-sufficiency

Anthracite, bituminous coal and lignite, helium, natural gas, petroleum, aluminum ores, antimony, arsenic, beryllium, bismuth, cadmium, cesium-rubidium, copper, gallium, germanium, gold, indium, iron ore, lead, magnesium, manganese, mercury, molybdenum, nickel, platinum metals, rare earth metals, selenium, silver, tellurium, thallium, titanium (ilmenite), titanium (rutile), zinc, zirconium, barite, boron minerals, bromine, corundum, fluorspar, graphite (strategic) iodine, jewel bearings, kyanite (strategic), lithium (spodumene), mica (strategic), nitrates, phosphate rock, potash, quartz crystal (radio grade), salt, steatite talc (for grinding), steatite talc (block), strontium minerals, sulfur.

Senator MALONE. Now, under the "Potential" heading, moving to B, "Complete or virtual dependence on foreign sources," I find there one commodity, industrial diamonds. Would you give us some idea of how that might be handled?

Mr. ZINNER. Yes. The possibility of synthesizing industrial diamonds simply has not appeared to us yet. However, there is some possibility of developing hard materials that will do the same work. Also, there is some latitude for conserving our use of industrial diamonds or at least cut down the demand. But on the basis of the present definition of industrial diamond end use, the commodity still remains in this column. This does not infer, of course, that we cannot improve the situation by either discovering how to synthesize diamonds or by developing a material that will do most of the work that these industrial diamonds will do.

Senator MALONE. What approaches have you made already and what materials approach the hardness of diamonds?

Mr. ZINNER. We have a relatively small program going on in two spots on this subject.

Senator MALONE. This is laboratory work?

Mr. ZINNER. Basic laboratory work.

Senator MALONE. Just the same as you did in titanium and electrolytic manganese until you had perfected this process?

Mr. ZINNER. Exactly.

Senator MALONE. What is the status generally speaking of this program?

Mr. ZINNER. It is very small.

Senator MALONE. It is encouraging?

Mr. ZINNER. Yes. We would not be working on it if we did not have some faith in it.

Senator MALONE. Yesterday somebody called the Korean war an incident. It has been called a police action and everything else. I was only in the First World War, but when they start to shoot men indiscriminately they should call it a war. In my opinion, if we have another war it will be the fourth. There are headlines every day that certain nations are becoming more dangerous all the time. Would you say that we should enlarge the capacity for the laboratory work in this industrial diamond field? Might important results be obtained by so doing?

Mr. ZINNER. I would rather not refer to it as the industrial diamond program, but I think the whole program on hard materials might very well be expanded. I say that for the simple reason that there are a number of important byproducts to this program involving the investigation of refractories and hard materials that are going into jet engines and other machines. These can be developed along this path in developing harder and more abrasive material.

Senator MALONE. Would you say from your background of experience, which we all know to be considerable in the entire field of minerals, that you could look forward with considerable hope of producing a material which might either displace or could be used in place of industrial diamonds if given a free hand in this field?

Mr. ZINNER. I think there is hope. I do not know the answer to it at the moment. I wish I did. I think we never will know unless we have continuous research programs in that field.

Senator MALONE. You would say then it is worth the effort.

Mr. ZINNER. Yes, sir; very much so.

Senator MALONE. Being in the engineering business for 30 years, I know how conservative an engineer is when he is responsible for his answers. You, being an expert in this field, are responsible.

Will you tell us something about this industrial diamond problem with respect to the matter of weight and transportation facilities? Suppose we never did supplant the industrial diamonds, could we not transport whatever is necessary by planes?

Mr. ZINNER. That is right. With your permission, when we get into this field I think the proper commodity man can give you better answers than I on that subject.

Senator MALONE. But it does come into the category of very little tonnage.

Mr. ZINNER. That is right.

Senator MALONE. One plane, if it was loaded with industrial diamonds, would take care of our needs for quite a little while.

Mr. ZINNER. That is correct. It is a very easy commodity to stockpile, too.

Senator MALONE. Now, passing on to heading C under "Western Hemisphere—Potential—C. Partial Dependence on Foreign Sources." Under that we find chromite, cobalt, columbium, tantalum, tin, tungsten, asbestos. We finally come down to a very reasonable list.

Did we not become almost self-sufficient in the production of chromite at one time during World War II?

Mr. ZINNER. First, I would like to qualify this word "partial." We have made no indication here whether partial represents 1 percent or 100 percent. Furthermore, we know very little, in this area of ferroalloy materials, about the degree of substitutability between the commodities. It was with some hesitation that we included any of these materials in this list. Current use and current knowledge have probably been given too much weight in this selection. The possibility of improving the degree of "partial" dependence in some commodities is very good. Asbestos, for example. There is some hope of complete synthesizing asbestos.

Senator MALONE. In other words, a synthetic product would replace it entirely in case of an emergency.

Mr. ZINNER. It is quite possible.

Senator MALONE. This is a conservative list?

Mr. ZINNER. Yes.

Senator MALONE. It is a very small list, too, is it not?

Mr. ZINNER. That is correct.

Senator MALONE. The chairman of this committee was special consultant to the Military Affairs Committee during World War II, and we examined chromite very closely. Chromite mined in this country is generally low grade; that is true, is it not?

Mr. ZINNER. I think an important problem in employing domestic chromite—and again I may stand corrected when the expert describes this subject—has been the ratio between iron and chromium in domestic ores. We have some reason to believe that the industry use pattern involving chromium might be corrected. Maybe we can learn how to use our domestic product regardless of current specifications. It is quite possible that some of our domestic sources which we have not considered as ores might very well be the commercial ores of the future, and be in great demand. I think much of our difficulty has hinged on the specifications for commercial chromite. I am not sure that the specifications have much in common with end use at the moment.

Senator MALONE. I do know something about chromite unless the situation has changed in recent years. I have not personally investigated it since World War II. Specifications of 45 to 47 percent were issued which, of course, eliminated much of the domestic production.

Mr. ZINNER. There were specifications on the chrome-iron ratio also.

Senator MALONE. That is correct. Before we leave this mineral for the expert who will testify later, and producers of chromite whom we will hear tomorrow, I found that the Rustless Iron & Steel Corp., of Baltimore, the largest producer of stainless steel, had a process where instead of making a special product out of high-grade chromite, this producer could use a low-grade chromite, as low as 30 percent, direct into the furnace regardless of the iron content.

Mr. ZINNER. That is absolutely right. That is the very thing that causes us to question the specifications on some of these ores when we relate them to ultimate resources. I think you could say the same

thing with iron ore. After all, the specifications are simply set up on past practices and, of course, on economics.

Senator MALONE. In other words, what you are trying to tell us is that you have based this list in part at least on present specifications, regardless of whether they are right or wrong, and you think in many cases the specifications could be changed to use domestic ores or ores produced in the western hemisphere?

Mr. ZINNER. Yes. Again this is one of the problems that bothers us in interpreting this word "commercial."

Senator MALONE. That is true. Is it not a fact that your electrolytic manganese could be used in place of ferromanganese if of necessity they had to convert to its use? In like manner instead of ferrochrome made from very high-grade chrome, 45 or 47 percent, which must be imported in most cases, low-grade chromite could be used direct in the furnace. While the use of chromite or manganese of lower grade might require a conversion to a certain extent in industry, can it be done without any great hardship?

Mr. ZINNER. In the case of manganese it does not even require a conversion. I think we proved that. We made electrolytic manganese from ores as low as 15 percent manganese.

Senator MALONE. Chemically pure manganese?

Mr. ZINNER. Manganese metal.

Senator MALONE. Metallic manganese.

Mr. ZINNER. Yes.

Senator MALONE. 99.99 percent or some fantastic purity.

Mr. ZINNER. That is correct. Then we took this metal to the industry and they substituted it for ferro manganese by introducing it into the bath in a simple fashion. In each case we showed that it could be satisfactorily used if available in adequate quantities and at a suitable price. This is a matter of record. We have this information describing the experience with industry in the use of electrolytic manganese published.

Senator MALONE. We will probably hear later in expressive words what some producers think of the specifications laid down by certain bureau officials. I have heard it expressed so many times in my own private engineering affairs, that those so-and-so officials laid down specifications which domestic commercial producers cannot meet. I would not say that they do it deliberately. I think they do it through ignorance.

Mr. ZINNER. I think it is often habit built up in the industry.

Senator MALONE. When we call in a lot of college professors to head commissions, and they have no firsthand knowledge of the industry, they simply set up the specifications based on customary use which automatically cuts out certain domestic production. Is that about right?

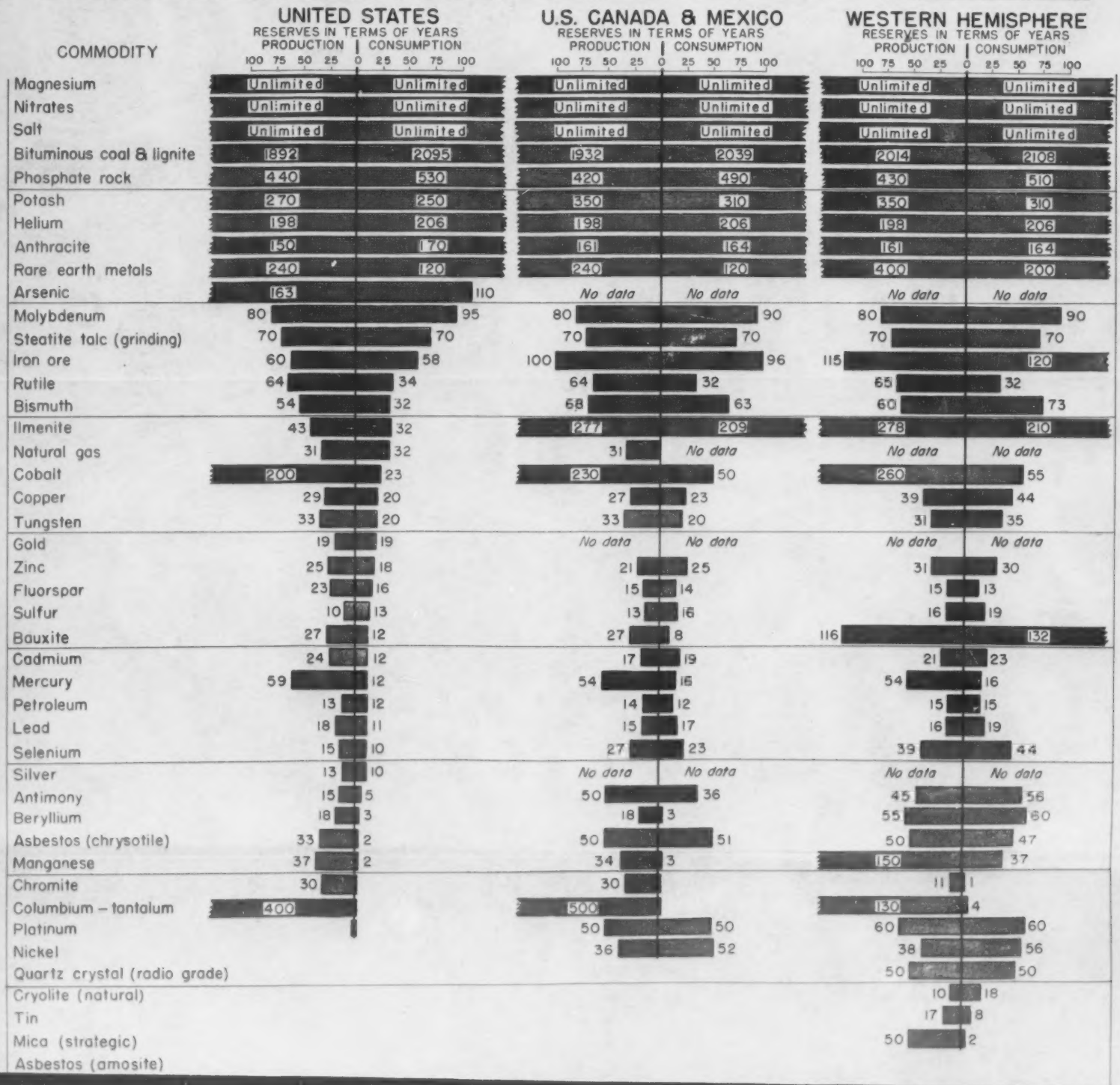
Mr. ZINNER. I think that is probably true in a good many of these cases.

Senator MALONE. So what we are trying to do in this committee is to determine if there is an all-out war, what can be produced in the United States and the Western Hemisphere where the lines of transportation can be kept open. I think your testimony is very important in that regard.

Certain articles in the newspapers make me angry. For example, in this morning's Wall Street Journal there is a headline that molyb-

ESTIMATED "COMMERCIAL" RESERVES COMPARED WITH 1948-52 AVERAGE ANNUAL RATES OF PRODUCTION AND CONSUMPTION

Figures indicate only order of magnitude of estimated reserves. They do not imply that production of rates indicated could be maintained for the full period shown. Estimates do not include allowance for future discoveries.


COMMODITY
UNITED STATES
RESERVES IN TERMS OF YEARS
PRODUCTION | CONSUMPTION
100 75 50 25 0 25 50 75 100
U.S. CANADA & MEXICO
RESERVES IN TERMS OF YEARS
PRODUCTION | CONSUMPTION
100 75 50 25 0 25 50 75 100
WESTERN HEMISPHERE
RESERVES IN TERMS OF YEARS
PRODUCTION | CONSUMPTION
100 75 50 25 0 25 50 75 100
Magnesium Unlimited Unlimited Unlimited Unlimited Unlimited Unlimited
Nitrates Unlimited Unlimited Unlimited Unlimited Unlimited Unlimited
Salt Unlimited Unlimited Unlimited Unlimited Unlimited Unlimited
Bituminous coal & lignite 1892 2095 1932 2039 2014 2108
Phosphate rock 440 530 420 490 430 510
Potash 270 250 350 310 350 310
Helium 198 206 198 206 198 206
Anthracite 150 170 161 164 161 164
Rare earth metals 240 120 240 120 400 200
Arsenic 163 110 No data No data No data No data
Molybdenum 80 95 80 90 80 90
Steatite talc (grinding) 70 70 70 70 70 70
Iron ore 60 58 100 96 115 120
Rutile 64 34 64 32 65 32
Bismuth 54 32 68 63 60 73
Ilmenite 43 32 277 209 278 210
Natural gas 31 32 31 No data No data No data
Cobalt 200 23 230 50 260 55
Copper 29 20 27 23 39 44
Tungsten 33 20 33 20 31 35
Gold 19 19 No data No data No data No data
Zinc 25 18 21 25 31 30
Fluorspar 23 16 15 14 15 13
Sulfur 10 13 13 16 16 19
Bauxite 27 12 27 8 116 132
Cadmium 24 12 17 19 21 23
Mercury 59 12 54 16 54 16
Petroleum 13 12 14 12 15 15
Lead 18 11 15 17 16 19
Selenium 15 10 27 23 39 44
Silver 13 10 No data No data No data No data
Antimony 15 5 50 36 45 56
Beryllium 18 3 18 3 55 60
Asbestos (chrysotile) 33 2 50 51 50 47
Manganese 37 2 34 3 150 37
Chromite 30 30 11 1
Columbium – tantalum 400 500 130 4
Platinum 50 50 60 60
Nickel 36 52 38 56
Quartz crystal (radio grade) 50 50
Cryolite (natural) 10 18
Tin 17 8
Mica (strategic) 50 2
Asbestos (amosite)

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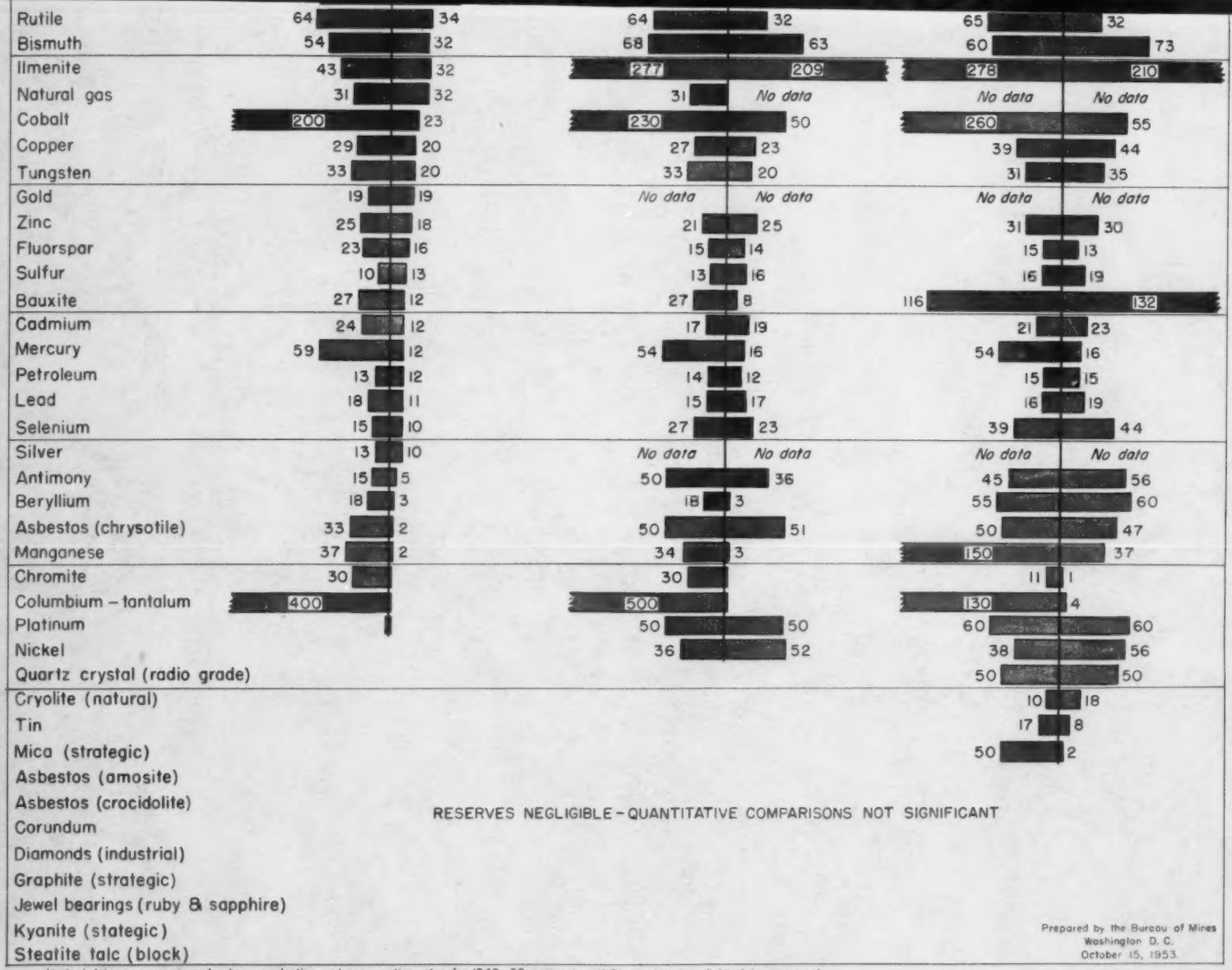
Rutile 64 34 64 32 65 32
Bismuth 54 32 68 63 60 73
Ilmenite 43 32 277 209 278 210
Natural gas 31 32 31 No data No data No data
Cobalt 200 23 230 50 260 55
Copper 29 20 27 23 39 44
Tungsten 33 20 33 20 31 35
Gold 19 19 No data No data No data No data
Zinc 25 18 21 25 31 30
Fluorspar 23 16 15 14 15 13
Sulfur 10 13 13 16 16 19
Bauxite 27 12 27 8 116 132
Cadmium 24 12 17 19 21 23
Mercury 59 12 54 16 54 16
Petroleum 13 12 14 12 15 15
Lead 18 11 15 17 16 19
Selenium 15 10 27 23 39 44
Silver 13 10 No data No data No data No data
Antimony 15 5 50 36 45 56
Beryllium 18 3 18 3 55 60
Asbestos (chrysotile) 33 2 50 51 50 47
Manganese 37 2 34 3 150 37
Chromite 30 30 11 1
Columbium – tantalum 400 500 130 4
Platinum 50 50 60 60
Nickel 36 52 38 56
Quartz crystal (radio grade) 50 50
Cryolite (natural) 10 18
Tin 17 8
Mica (strategic) 50 2
Asbestos (amosite)
Asbestos (crocidolite)
Corundum
Diamonds (industrial)
Graphite (strategic)
Jewel bearings (ruby & sapphire)
Kyanite (stategic)
Steatite talc (block)
RESERVES NEGLIGIBLE – QUANTITATIVE COMPARISONS NOT SIGNIFICANT
Prepared by the Bureau of Mines
Washington D. C.
October 15, 1953.

39888 O - 53 pt. 1 (Face p. 44) No. 1

*Latest data on reserves used; where production and consumption rates for 1948 – 52 were not available the latest available data were used.

HTIW CERAMICO CNA MOTICUDORP OT RHODUCTION AND
ESTIMATED "COMMERCIAL" RESERVES COMPARED WITH
1978-52 SURFACE ANNUAL RATES OF PRODUCTION AND

MINERAL POSITIONS—ACTUAL, IMPENDING, AND POTENTIAL

(Based on "commercial" reserves, outlook for noteworthy discovery, and the possibility that known submarginal resources can be made available by technologic progress and improved economic

RELATIVE SELF-SUFFICIENCY

UNITED STATES

ACTUAL AND IMPENDING

(Based on present technologic and economic conditions and on "commercial" reserves)

A. VIRTUAL SELF-SUFFICIENCY ASSURED FOR A LONG TIME:

Anthracite
Bituminous coal and lignite
Helium
Natural gas
Petroleum
Arsenic
Gallium
Indium
Magnesium
Molybdenum
Tellurium
Thallium
Titanium (ilmenite)
Zirconium
Boron minerals
Bromine
Lithium (spodumene)
Nitrates
Phosphate rock
Potash
Salt
Steatite talc (for grinding)
Sulfur

B. COMPLETE OR VIRTUAL DEPENDENCE OR FOREIGN SOURCES:

1. Small or remote expectation of improving position through discovery:

Beryllium
Chromite
Manganese
Nickel
Platinum metals
Tin
Asbestos
Corundum
Diamonds (industrial)
Graphite (strategic)
Jewel bearings
Kyanite (strategic)
Mica (strategic)
Quartz crystal (radio grade)
Steatite talc (block)

2. Good expectation of improving position through discovery:

Columbium-Tantalum
Strontium minerals

3. Good expectation of improving position through synthesis:

Corundum
Kyanite (strategic)
Mica (strategic)
Quartz crystal (radio grade)
Steatite talc (block)

C. PARTIAL DEPENDENCE ON FOREIGN SOURCES, ACTUAL OR IMPENDING:

1. Good expectation of improving position through discovery:

Cadmium
Cobalt
Copper
Germanium
Gold
Iron ore
Lead
Mercury
Rare earth metals
Selenium
Silver
Tungsten
Zinc
Barite
Fluorspar
Iodine

2. Little hope of improving position through discovery:

Aluminum ore
Antimony
Bismuth
Cesium-Rubidium
Titanium (rutile)

POTENTIAL

(If technologic and economic changes permit use of known submarginal resources)

A. VIRTUAL SELF-SUFFICIENCY:

Anthracite
Bituminous coal and lignite
Helium
Natural gas
Petroleum
Aluminum ores
Arsenic
Beryllium
Cadmium
Gallium
Germanium
Gold
Indium
Iron ore
Lead
Magnesium
Manganese
Molybdenum
Rare earth metals
Selenium
Tellurium
Thallium
Titanium (ilmenite)
Titanium (rutile)
Zinc
Zirconium
Barite
Boron minerals
Bromine
Corundum
Graphite (strategic)
Iodine
Jewel bearings
Kyanite (strategic)
Lithium (spodumene)
Nitrates
Phosphate rock
Potash
Quartz crystal (radio grade)
Salt
Steatite talc (for grinding)
Steatite talc (block)
Strontium minerals
Sulfur

B. COMPLETE OR VIRTUAL DEPENDENCE ON FOREIGN SOURCES:

Nickel
Platinum metals
Tin
Asbestos
Diamonds (industrial)

C. PARTIAL DEPENDENCE ON FOREIGN SOURCES:

Antimony
Bismuth
Cadmium
Cesium-Rubidium
Chromite
Cobalt
Columbium-Tantalum
Copper
Gold
Lead
Mercury
Silver
Tungsten
Zinc
Fluorspar
Mica (strategic)

UNITED STATES, CANADA AND MEXICO

ACTUAL AND IMPENDING

(Based on present technologic and economic conditions and on "commercial" reserves)

A. VIRTUAL SELF-SUFFICIENCY ASSURED FOR A LONG TIME:

Anthracite
Bituminous coal and lignite
Helium
Natural gas
Petroleum
Arsenic
Cadmium
Gallium
Gold
Indium
Lead
Magnesium
Molybdenum
Nickel
Selenium
Silver
Tellurium
Thallium
Titanium (ilmenite)
Zinc
Zirconium
Barite
Boron minerals
Bromine
Lithium (spodumene)
Nitrates
Phosphate rock
Potash
Salt
Steatite talc (for grinding)
Sulfur

B. COMPLETE OR VIRTUAL DEPENDENCE ON FOREIGN SOURCES:

1. Small or remote expectation of improving position through discovery:

Beryllium
Chromite
Manganese
Tin
Corundum
Diamonds (industrial)
Graphite (strategic)
Jewel bearings
Kyanite (strategic)
Mica (strategic)
Quartz crystal (radio grade)
Steatite talc (block)

2. Good expectation of improving position through discovery:

Columbium-Tantalum

3. Good expectation of improving position through synthesis:

Corundum
Kyanite (strategic)
Mica (strategic)
Quartz crystal (radio grade)
Steatite talc (block)

C. PARTIAL DEPENDENCE ON FOREIGN SOURCES, ACTUAL OR IMPENDING:

1. Good expectation of improving position through discovery:

Antimony
Bismuth
Cobalt
Copper
Germanium
Iron ore
Mercury
Platinum metals
Rare earth metals
Tungsten
Asbestos
Fluorspar
Iodine
Strontium minerals

2. Little hope of improving position through discovery:

Aluminum ore
Cesium-Rubidium
Titanium (rutile)

POTENTIAL

(If technologic and economic changes permit use of known submarginal resources)

A. VIRTUAL SELF-SUFFICIENCY:

Anthracite
Bituminous coal and lignite
Helium
Natural gas
Petroleum
Aluminum ores
Antimony
Arsenic
Beryllium
Cadmium
Copper
Gallium
Germanium
Gold
Indium
Iron ore
Lead
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Rare earth metals
Selenium
Silver
Tellurium
Thallium
Titanium (ilmenite)
Titanium (rutile)
Zinc
Zirconium
Barite
Boron minerals
Bromine
Corundum
Fluorspar
Graphite (strategic)
Iodine
Jewel bearings
Kyanite (strategic)
Lithium (spodumene)
Nitrates
Phosphate rock
Potash
Quartz crystal (radio grade)
Salt
Steatite talc (for grinding)
Steatite talc (block)
Strontium minerals
Sulfur

B. COMPLETE OR VIRTUAL DEPENDENCE ON FOREIGN SOURCES:

Tin
Diamonds (industrial)

C. PARTIAL DEPENDENCE ON FOREIGN SOURCES:

Bismuth
Cesium-Rubidium
Chromite
Cobalt
Columbium-Tantalum
Platinum metals
Tungsten
Asbestos
Mica (strategic)

MINERAL FACTORS—ACTUAL, DEPENDING, AND POTENTIAL

noteworthy discovery, and the possibility that known submarginal resources can be made available by technologic progress and improved economic conditions)

RELATIVE SELF-SUFFICIENCY

UNITED STATES, CANADA AND MEXICO

ACTUAL AND DEPENDING

(Based on present technologic and economic conditions and on "commercial" reserves)

VIRTUAL SELF-SUFFICIENCY ASSURED FOR A LONG TIME:

[illegible]cite
[illegible]minous coal
[illegible] lignite
[illegible]m
[illegible]al gas
[illegible]oleum
Arsenic
Cadmium
Gallium
Gold
Indium
Lead
Magnesium
Molybdenum
Nickel
Selenium
Silver
Tellurium
Thallium
Titanium (ilmenite)
Zinc
Zirconium
Barite
Boron minerals
Bromine
Lithium (spodumene)
Nitrates
Phosphate rock
Potash
Salt
Steatite talc (for grinding)
Sulfur

COMPLETE OR VIRTUAL DEPENDENCE ON FOREIGN SOURCES:

Small or remote expectation of improving position through discovery:

Beryllium
Chromite
Manganese
Tin
Corundum
Diamonds (industrial)
Graphite (strategic)
Jewel bearings
Kyanite (strategic)
Mica (strategic)
Quartz crystal (radio grade)
Steatite talc (block)

Good expectation of improving position through discovery:

Columbium-Tantalum

Good expectation of improving position through synthesis:

Corundum
Kyanite (strategic)
Mica (strategic)
Quartz crystal (radio grade)
Steatite talc (block)

PARTIAL DEPENDENCE ON FOREIGN SOURCES, ACTUAL OR DEPENDING:

Good expectation of improving position through discovery:

Antimony
Bismuth
Cobalt
Copper
Germanium
Iron ore
Mercury
Platinum metals
Rare earth metals
Tungsten
Asbestos
Fluorspar
Iodine
Strontium minerals

Little hope of improving position through discovery:

Aluminum ore
Cesium-Rubidium
Titanium (rutile)

POTENTIAL

(If technologic and economic changes permit use of known submarginal resources)

A. VIRTUAL SELF-SUFFICIENCY:

Anthracite
Bituminous coal and lignite
Helium
Natural gas
Petroleum
Aluminum ores
Antimony
Arsenic
Beryllium
Cadmium
Copper
Gallium
Germanium
Gold
Indium
Iron ore
Lead
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Rare earth metals
Selenium
Silver
Tellurium
Thallium
Titanium (ilmenite)
Titanium (rutile)
Zinc
Zirconium
Barite
Boron minerals
Bromine
Corundum
Fluorspar
Graphite (strategic)
Iodine
Jewel bearings
Kyanite (strategic)
Lithium (spodumene)
Nitrates
Phosphate rock
Potash
Quartz crystal (radio grade)
Salt
Steatite talc (for grinding)
Steatite talc (block)
Strontium minerals
Sulfur

B. COMPLETE OR VIRTUAL DEPENDENCE ON FOREIGN SOURCES:

Tin
Diamonds (industrial)

C. PARTIAL DEPENDENCE ON FOREIGN SOURCES:

Bismuth
Cesium-Rubidium
Chromite
Cobalt
Columbium-Tantalum
Platinum metals
Tungsten
Asbestos
Mica (strategic)

EASTERN HEMISPHERE

ACTUAL AND DEPENDING

(Based on present technologic and economic conditions and on "commercial" reserves)

A. VIRTUAL SELF-SUFFICIENCY ASSURED FOR A LONG TIME:

Anthracite
Bituminous coal and lignite
Helium
Natural gas
Petroleum
Aluminum ores
Antimony
Arsenic
Beryllium
Bismuth
Cadmium
Copper
Gallium
Gold
Indium
Iron ore
Lead
Magnesium
Molybdenum
Nickel
Platinum metals
Rare earth metals
Selenium
Silver
Tellurium
Thallium
Titanium (ilmenite)
Zinc
Zirconium
Barite
Boron minerals
Bromine
Lithium (spodumene)
Nitrates
Phosphate rock
Potash
Quartz crystal (radio grade)
Salt
Steatite talc (for grinding)
Sulfur

B. COMPLETE OR VIRTUAL DEPENDENCE ON FOREIGN SOURCES:

1. Small or remote expectation of improving position through discovery:

Chromite
Corundum
Diamonds (industrial)
Graphite (strategic)
Jewel bearings
Kyanite (strategic)
Steatite talc (block)

2. Good expectation of improving position through discovery:

3. Good expectation of improving position through synthesis:

Corundum
Kyanite (strategic)
Steatite talc (block)

C. PARTIAL DEPENDENCE ON FOREIGN SOURCES, ACTUAL OR DEPENDING:

1. Good expectation of improving position through discovery:

Cesium-Rubidium
Cobalt
Columbium-Tantalum
Germanium
Manganese
Mercury
Tin
Titanium (rutile)
Tungsten
Asbestos
Fluorspar
Iodine
Mica (strategic)
Strontium minerals

POTENTIAL

(If technologic and economic changes permit use of known submarginal resources)

A. VIRTUAL SELF-SUFFICIENCY:

Anthracite
Bituminous coal and lignite
Helium
Natural gas
Petroleum
Aluminum ores
Antimony
Arsenic
Beryllium
Bismuth
Cadmium
Cesium-Rubidium
Copper
Gallium
Germanium
Gold
Indium
Iron ore
Lead
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Platinum metals
Rare earth metals
Selenium
Silver
Tellurium
Thallium
Titanium (ilmenite)
Titanium (rutile)
Zinc
Zirconium
Barite
Boron minerals
Bromine
Corundum
Fluorspar
Graphite (strategic)
Iodine
Jewel bearings
Kyanite (strategic)
Lithium (spodumene)
Mica (strategic)
Nitrates
Phosphate rock
Potash
Quartz crystal (radio grade)
Salt
Steatite talc (for grinding)
Steatite talc (block)
Strontium minerals
Sulfur

B. COMPLETE OR VIRTUAL DEPENDENCE ON FOREIGN SOURCES:

Diamonds (industrial)

C. PARTIAL DEPENDENCE ON FOREIGN SOURCES:

Chromite
Cobalt
Columbium-Tantalum
Tin
Tungsten
Asbestos

Prepared by the Bureau of Mines
Washington, D. C.
October 15, 1953

PERCENTAGE DISTRIBUTION, BY COUNTRIES AND GEOGRAPHIC AREAS, OF WORLD PRODUCTION

OF SELECTED CRITICAL METALS AND MINERALS IN 1952

	Aluminum	Antimony	Asbestos	Bauxite	Beryllium	Bismuth	Cadmium	Chromite	Cobalt	Columbium	Copper, mine	Copper, smelter	Corundum	Diamonds, Industrial	Fluorspar	Graphite	Iron ore	Lead, mine	Lead, smelter	Magnesium metal	Manganese	Mercury	Mica, including scrap	Molybdenum	Nickel	Petroleum, crude	Platinum-group metals	Potash, K2O equiv.	Sulfur	Talc, Pyrophyllite and Soapstone	Tantalite	Tin, mine	Tin, smelter	Titanium: Ilmenite
North America:																																	
Canada	22.1	2.5	59.2			4.5	7.3		5.9		5.5	6.3			6.4	1.0	1.6	5.2	9.3	[a]3.3			0.4	0.6	73.4	1.4	39.9			1.6		0.1	0.1	4.3
United States	41.5	4.3	3.4	11.2	7.1	**	61.9	0.6	3.8	[b]0.2	30.7	32.8			28.4	2.7	33.5	19.4	21.9	63.6	1.4	4.1	57.1	[c]4.4	0.7	50.9	5.1	27.6	[d]5.0	17.0	[b]	0.1	11.4	53.7
Total	63.6	6.8	62.6	11.2	7.1	4.5	69.2	0.6	9.7	0.2	36.2	39.1			31.8	3.7	38.1	27.6	31.2	66.9	1.4	4.1	57.2	4.0	73.7	52.3	45.0	27.6	22.6	18.6		0.2	11.6	58.0
Middle America:																																	
Central America:																																	
El Salvador																		[a]0.2															
Guatemala								•										•	•														
Honduras																						**											
Mexico		12.0				16.9			0.1		2.1	1.8			15.1	12.7	0.2	13.5	13.2		1.3	5.8	**			[a]1.7			0.2			0.2	0.1	
West Indies:																																	
Cuba								1.9			0.7						•	**			[a]3.3				4.7	**							
Jamaica				[a]2.7																						0.5							
Trinidad																																	
Total		12.0		2.7		16.9		1.9	0.1		2.8	1.8			15.1	12.7	0.2	13.7	13.2		4.6	5.8	**		4.7	0.2			0.2			0.2	0.1	
South America:																																	
Argentina		**	**		[c]7.6	**		**		**			**		**	**	**	1.0	1.1		**		1.2			0.6			[d]0.1	[a]1.1		[a]0.1	[a]0.2	
Bolivia		[d]21.3	•			**		**			[d]0.2				**			[d]1.6				**				•			[d]0.1			[a]16.5	[a]0.1	
Brazil	•		**	**	[d]38.6	**		**		[c]0.1			**	0.6	**	**	1.0	**	**		[d]0.1				**		•				[a]0.4	[a]0.1	[a]0.1	**
British Guiana				18.9										0.1																				
Chile			**		**						14.8	13.5					0.7	[a]0.2			0.5	**		7.4		•		**					
Colombia																		•								0.9	4.4						
Ecuador																		[a]4.4	2.7		•	**		**		[a]0.1			•			•	•
Peru		1.1				17.8					1.1	0.7														[a]0.4			0.1				
Surinam				24.6																													
Uruguay			•																				•										
Venezuela														0.3			0.7									[b]7.7							
Total	•	22.4	•	43.5	45.2	17.8		**		0.1	18.1	14.2	**	0.9	**	**	2.4	8.2	3.8		2.6	**	1.2	7.4	**	18.7	4.4	**	4.9	1.1	63.5	18.7	0.4	**
TOTAL WESTERN HEMISPHERE	63.6	41.2	62.6	59.4	53.3	39.2	69.2	2.5	9.8	0.3	58.1	55.1	**	0.9	46.9	16.4	37.7	40.5	50.2	66.9	8.6	11.2	60.1	96.4	74.1	71.2	10.9	37.6	23.5	19.7	63.4	19.1	14.0	58.0
Europe:																																	
Albania								**																		•							
Austria	1.8	[a]0.8		0.1							0.1	0.2				10.4	0.9	0.3	[f]0.6			**	**	0.1		[a]0.5			3.4				
Belgium							[a]3.5								**		•		[f]1.2													6.2	
Bulgaria								**									**				**												
Cyprus			[d]1.3					[d]0.4			[d]1.0																						
Czechoslovakia		**	[d]**														**	[a]0.7	**	**		**				[a]•							
Finland			0.4						**		0.8	0.6						•						**	0.2								
France	5.2	**	0.4	8.7	**	**	[a]1.6				**	**			4.8		13.9	0.6	2.9	0.7				**		0.1		19.2	0.2	6.5		[a]0.2		
Germany, East	**					**					**	**			**		**	**	**									**				[a]0.2		
Germany, West	4.9			•		**	[a]1.1				0.1	[f]6.9			13.2	4.7	5.2	2.8	5.2							0.3		21.2		0.7			[a]0.6	
Greece		0.8	•	2.7				0.9									•	0.3	0.1		[a]0.1					0.1				0.1				
Hungary	**	**		**							**						[a]0.1	**	**							[a]0.1							
Italy	2.6	1.7	1.7	2.2			2.1		**		•	•			4.9	2.1	0.3	2.2	1.9	0.6	0.5	37.2	**			•		**	3.9	5.4				
Luxembourg																	2.4																
Netherlands																										0.1						16.3	
Norway	2.5				**		[a]1.6				0.5	0.4				2.2	0.3	•		0.9			0.9	0.5						[a]0.1			13.4
Poland							[a]3.8										[a]0.3	1.1	1.1							[a]•							•
Portugal		**	**		1.2			**									**	**	**		0.1									**		0.6	[a]0.2	
Rumania				**		**											[a]0.2	**	**			**	**	**		[a]0.7							
Spain	0.2	1.4	**	•		**	[a]0.1				0.3	0.2			6.2	0.3	1.0	[f]2.4	2.6		[f]0.4	25.1	•	**				3.1	0.1	1.9		0.3	0.4	0.4
Sweden	0.4					**					0.6	0.6			**	**	[a]0.9	1.1	0.6		**		**	**						**				
Switzerland	1.4																[a]16.6			0.2													
U. S. S. R.	[a]12.2		**	**		**	[a]1.4	h			[a]16.8	[a]10.4	**			**	5.5	[a]5.5	[a]1.6	**			**	**	**		[a]14.5	[h]7.4	[a]14.8	**	**			
United Kingdom	1.4					**	2.5	**							6.5		[a]0.2	0.2	[a]0.2	3.2						•						0.6	[f]17.3	
Yugoslavia	0.1	5.9	0.2	4.5		5.5		3.4			1.2	1.2				0.4	0.2	4.1	3.7		0.2	0.7				•								
Total	32.7	10.6	4.0	18.2	1.2	6.5	23.7	4.7	**		19.4	20.6	**		35.6	20.1	53.7	23.8	21.7	5.6	11.8	73.0	0.6	0.6	14.7	9.2	14.6	50.5	4.2	22.1		1.9	31.0	1.7
Africa:																																	
Algeria		2.9									•						1.0	0.2				**				•							
Angola											•	•		1.9							0.7												
Belgian Congo						**	[a]0.3		[e]3.3	6.8	7.5	7.3		70.9							[a]1.0			0.2			**					8.0	1.6	
Egypt			**													**					0.7					0.4	•	**		9.3				**
Ethiopia																																	
French Cameroons																																	
Fr. Eq. Africa										0.1			**	8.9				0.2													•		
French Morocco		1.8	•		2.0				10.0		•			0.7	0.3	•	0.2	4.6	1.7		5.5		•		0.1	•					•		
Fr. West Africa				0.9																											[a]0.1		
Gold Coast				[d]0.6										11.8							[d]10.3												
Kenya			•													•							•						•				
Liberia																	0.1																
Madagascar			•		6.0					0.2						9.7							0.9										
Mozambique				**	2.1					1.2			**					•					•										
Nigeria										[f]5.2																				2.4	[a]4.8			
Northern Rhodesia					0.1				5.9		12.0	11.2					•	0.7	0.7		0.1		•			•					•			
Nyasaland													0.5																					
Senegal																											**							
Sierra Leone								0.7						2.0			0.5																	
Southern Rhodesia		0.2	5.4		16.5			10.1			•						•				•		0.6								10.9	•	•	
South-West Africa					[f]8.2	**					0.8		37.9	0.7	0.4	0.6		2.9			0.3											[a]6.6			
Spanish Morocco																	0.3	•			•											•		
Swaziland			2.2															[f]														[f]		
Tanganyika					**						•			0.4				•					[a]0.1											
Tunisia															0.2		0.3	1.3	1.4														
Uganda					•	[a]0.1				[c]0.2								•					•											
Union of South Africa		15.7	8.5		5.7	[a]0.1		18.1			1.3	1.2		3.7	0.3	0.2	0.6	•			11.4	**	2.2					[f]3.3			0.6	3.4		0.6	
Total		[e]0.6	16.1	1.5	[f]40.6	0.2	0.3	28.9	[e]4.2	[f]1.7	21.3	12.7	38.4	[f]2.2	1.8	10.5	3.2	10.1	3.3		[f]2.9		[f]4.0			0.2	0.4	[f]3.3	**		[f]0.2	[a]0.1	[f]3.4	[f]1.1	

...ENTAGE DISTRIBUTION, BY COUNTRIES AND GEOGRAPHIC AREAS, OF WORLD PRODUCTION

OF SELECTED CRITICAL METALS AND MINERALS IN 1952

Diamonds, industrial	Fluorspar	Graphite	Iron ore	Lead, mine	Lead, smelter	Magnesium metal	Manganese	Mercury	Mica, including scrap	Molybdenum	Nickel	Petroleum, crude	Platinum-group metals	Potash K_2O equiv.	Sulfur	Talc, Pyrophyllite and Soapstone	Tantalite	Tin, mine	Tin, smelter	Titanium Ilmenite	Titanium Rutile	Tungsten	Vanadium	Zinc, mine	Zinc, smelter
	6.4	1.0	1.6	5.2	9.3	[a]3.2			0.4	0.6	73.4	1.4	39.9		1.6		0.1	0.1	4.3	**	1.7	W.P.	13.2	9.2
	93.4	2.7	33.5	19.4	21.9	65.6	1.4	[c]1.4	57.1	[c]7.4	0.1	50.9	[c]1.1	27.5	[c]2.0	17.0	b	0.1	13.4	53.7	**	12.5	**	24.0	17.1
	31.8	3.7	35.1	27.6	31.2	66.9	1.4	[c]1.4	57.4	[c]9.0	73.7	[c]52.3	[c]40.9	27.5	[c]2.0	17.6		0.2	13.5	[c]54.0	**	14.2	**	37.2	26.5
				[a]0.2																					
				•	•			**																0.3	
	15.1	12.7	0.2	13.5	13.2		1.3	5.8	**			[a]1.7			0.2			0.2	0.1			0.8		9.0	2.4
			•	••			[a]3.3				4.7	••													
												0.5													
	15.1	12.7	0.2	13.7	13.2		4.6	5.8	**		4.7	2.2			0.2			0.2	0.1			0.8		9.3	2.4
	••	••	••	1.0	1.1		••		1.2			0.6			[a]0.1	[a]1.1		[a]0.1	[a]0.2			1.1	••	0.6	[a]0.4
	••			[d]1.6								•			[d]0.1			[d]8.5	[d]0.1			[d]6.7		[d]1.3	
0.6	••	••	1.0	••	••		[ad]2.1	••	••		••	•				••		[a]0.1	[a]0.1	••	••	[ad]3.2			
0.1															•										
			0.7	[a]0.2			0.5	••		7.4		•	4.9	••	0.6	••									
				•								0.9			•										
				5.4	2.7		•	••		••		0.1			0.1			•	•			1.1	49	4.8	0.2
									•			0.4				•									
0.6			0.7									[b]1.7													
0.9	••	••	2.4	8.2	3.8		2.6	••	1.2	7.4	••	16.7	4.9	••	0.9	1.1	52.4	18.7	0.4	••	••	12.1		5.7	0.5
0.9	46.9	16.4	37.7	49.5	50.2	66.9	8.6	14.2	[c]0.1	96.4	[c]1	71.2	40.9	27.5	19.7	19.7	52.4	19.1	14.0	58.0	••	27.1		53.2	49.5
												[a]o													
	••	10.4	0.9	0.3	[f]0.6			••	••	0.1		[a]0.5				3.4								0.2	
			•		[f]4.2														6.2						[f]5.5
			••				••																	••	
		••	[a]0.7	••	••			••				[a]•												••	••
			•							••															
	4.8		13.9	0.6	2.9	0.7				••	0.2	0.1		19.2	0.2	6.5		[a]0.2				0.1		[a]0.3	
	••		••	••	••									••				[a]0.2				[a]1.8		0.6	3.6
	13.2	4.7	5.2	2.8	5.2							0.3		27.2		0.7			[a]0.6					••	••
			•	0.3	0.1		[a]0.1					•				0.1								3.2	6.7
			[a]0.1	••	••		••					[a]0.1												0.3	
	4.9	2.1	0.3	2.2	1.9	0.6	0.5	37.2	••			•		••	3.9	5.4						•		4.5	2.6
			2.4									0.1							16.3						1.2
		2.2	0.3	•		0.9			0.4	0.5						[a]4.1				13.2	0.1			0.2	1.7
			[a]0.3	1.1	1.1							[a]•				••				•				3.4	4.3
			••	••	••		0.1											0.6	[a]0.2			8.8			
			[a]0.2	••	••		••	••	••	••		[a]0.7				••								••	••
	6.2	0.3	1.0	62.4	2.6		[a]0.4	28.1	•	••				3.1	0.1	1.9		0.3	0.4	0.1		4.3		[a]3.3	1.0
	••	••	8.9	1.1	0.6		••		••	••						••						[a]0.7		1.9	
		••	[b]16.8	[a]8.5	[a]1.6	0.2		[a]32.5	••	••	••	[a]14.5	[b]7.4	[a]14.8	••	••		••						••	[a]5.5
	6.5		5.5	0.2	[a]0.2	••							•					0.6	f17.3			0.1		[a]7.4	3.2
		0.4	0.2	4.3	3.7	3.2	0.2	9.7					•											••	0.7
	35.6	20.1	53.7	23.8	31.7	5.6	33.8	73.0	0.2	0.5	14.7	9.2	14.8	50.5	4.2	22.1		1.9	41.0	14.3	0.1	15.8		27.6	21.5
																								1.9	
			1.0	0.2				••				•										0.1		0.5	
1.9							0.7		0.2				••											•	
70.9							[a]1.0											8.0	1.6			[a]0.9		3.9	
		••					0.7					0.4				0.3				••		•			
													•	••				•			0.5				
8.9				0.2																					
	0.3	•	0.2	4.6	1.7		5.8		•		0.1	•						•				•		1.1	
0.7																		0.1							
11.8		•					d10.3		•							•									
			0.3																						
		9.7							0.9																
				•					•									•							
			•	0.7	0.7		0.1		•								2.4	4.8				•		•	
																		•					43	0.9	1.1
																				0.5	••				
2.0			0.5										••												
0.7	0.4	0.6	•	2.9			•		0.6								10.9	•	•			0.8			
							0.3										4.6	•				0.2	64	0.6	
			0.3	6			6											•							
0.4				[a]0.2					[a]0.1									[d]•				[d]•			
	0.2		0.3	1.3	1.4																			0.1	
				•					•									[d]•				[d]0.2			
3.7	0.9	0.2	0.6	•			11.4		2.2		0.8		[e]1.1			0.6	3.4	0.5	0.5			0.5			
99.0	1.8	10.5	3.2	10.1	1.1		32.9	••	4.0		0.9	0.4	35.1	••		0.9	[b]0.1	13.4	2.2	0.5	0.5	2.7		7.1	1.1

	Aluminum	Antimony	Asbestos	Bauxite	Beryllium	Bismuth	Cadmium	Chromite	Cobalt	Columbium	Copper, mine	Copper, smelter	Corundum	Diamonds, Industrial	Fluorspar	Graphite	Iron ore	Lead, mine	Lead, smelter	Magnesium metal	Manganese	Mercury	Mica, including scrap	Molybdenum	Nickel	Petroleum, crude	Platinum-group metals	Pyrites, gross	Sulfur	Talc, Pyrophyllite and Soapstone	Tantalite	Tin, mine	Tin, smelter	Titanium: Ilmenite	
Asia:																																			
Afghanistan								o																											
Bahrain Island		**									**															0.2				0.1				
Burma																		[a]0.1	0.1													0.6			
Ceylon																4.1							o												
China		17.4	**			**					[a]0.2	[af]0.2			e **	**	[a]1.3	**	[af]0.3	**	**	**	**	**	**	[a] .		*	**	**		[a]5.0	[a]4.7		
Hong Kong																																			
India	0.2	**	**	**	**			**		**	0.2	0.2	**			**	1.2		0.1		16.8		[d]12.1			*		*		**				**	
Indochina																																			
Indonesia				4.4																												0.1			
Iran		0.3						**										1.0			0.1					[a]0.2						70.2			
Iraq																										1.4									
Japan	2.1	0.5	0.3			2.4	[a]2.1	[a]1.5	**		1.9	1.7			0.3	2.1	0.4	1.0	0.8		[a]2.3	2.0		0.4		*	**		2.9	21.6		0.4	7.4		
Korea, North			**									**			**		**	**	**		**			**											
Korea, Republic of			**		*	5.5					*	*			0.5	[e]3	*	*	*		**		*	**											
Kuwait																										6.1									
Malaya				0.2				0.5		3.1			**				0.3									*									
Pakistan								17.0			0.5						0.4	0.1			0.1											32.8	36.7	[f]0.5	
Philippines																	[e]2				1.5														
Port. India																										2.6									
Qatar		**																								2.9									
Sarawak and Brunei																										0.7									
Saudi Arabia											**															*									
Taiwan	0.2		*	**							**	*				0.4				**			*						0.1	0.1					
Thailand		0.2															*	0.1														5.5			
Turkey		3.0						[a]19.8							**		0.2	[a]0.1		**	1.3	**		**		*			0.1						
U. S. S. R.		**	**	**		**		[a]16.4	**	3.1	0.8	0.8	**		**	**	1			**		**		**				*		**					
Total	2.5	21.4	0.3	4.6	*	7.9	2.1	57.6	**	3.1	3.6	2.9	**		0.8	14.9	1.0	2.4	1.3	**	22.3	2.0	12.1	0.8		10.2	**	**	3.1	22.1		38.5	41.5	0.5	
Oceania:																																			
Australia		0.4	0.3	0.1	1.4	0.1	4.7	**	**		0.7	0.6			*	**	0.9	12.7	11.0		[a]0.1		0.4	*			*	**			0.5	16.5	0.9	1.0	**	
Fiji Islands																					**														
New Caledonia								3.4									**				0.2														
New Guinea		**	**																						6.0	*	*								
New Zealand																	**				**					*	**								
Papua																					*														
Total		0.4	0.3	0.1	1.4	0.1	4.7	3.4	**		0.7	0.6			*	**	0.9	12.7	11.0		0.3		0.4	*	6.0	*	**	*		0.5	16.5	0.9	1.0	**	
Unidentified	1.2	5.8	16.7	16.2	1.5	47.1	0.0	2.9	6.0	2.9	0.9	1.2	61.6	0.1	18.9	38.1	0.5	1.5	2.0	27.6	2.1	10.4	27.6	2.6	0.7	0.0	0.0	0.0	2.0	3.3	18.7	4.8	0.1	0.0	25.7	
Total	100	[b]100	100	100	[b]100	100	100	100	[b]100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	[b]100	[b]100	100	
WORLD TOTALS	2,050,000 M.T.	16,000 M.T.	1,435,000 M.T.	12,837,000 M.T.	7,200 S.T.	1,600,000 Kgs.	6,280,000 Kgs.	3,200,000 M.T.	10,000 M.T.	3,400,000 Lbs.	2,735,000 M.T.	2,130,000 M.T.	10,000 M.T.	15,600,000 M.C.	1,190,000 M.T.	190,000 M.T.	297,000,000 M.T.	1,620,000 M.T.	1,796,000 M.T.	181,000 M.T.	7,700,000 M.T.	150,000 Flsk.	180,000 M.T.	27,200 M.T.	173,000 M.T.	4,491,057 1,000 bbls.	675,000 T.Oz.	5,500,000 M.T.	6,000,000 L.T.	1,475,000 M.T.	38,000 Lbs.	173,200 L.T.	178,600 L.T.	693,000 M.T.	

* Less than 0.1%.
** Data not available, estimate included in total.
e/ Estimate.
f/ Small quantity of tantalite is included in the columbium figure.
g/ United States imports.
h/ Exports.
i/ Data for Soviet Zone of Austria included in total.
j/ Includes scrap.
k/ Spanish Morocco is included in the Spanish figure.
l/ U. S. S. R. in Europe included with U. S. S. R. in Asia.
m/ U. S. S. R. in Asia included with U. S. S. R. in Europe.
n/ U. S. S. R. not included in world total.

Fluorspar	Graphite	Iron ore	Lead, mine	Lead, smelter	Magnesium metal	Manganese	Mercury	Mica, including scrap	Molybdenum	Nickel	Petroleum, crude	Platinum-group metals	Potash	Sulfur	Talc, pyrophyllite and soapstone	Tantalite	Tin, mine	Tin, smelter	Titanium: Ilmenite	Titanium: Rutile	Tungsten	Vanadium	Zinc, mine	Zinc, smelter
			[a]0.1	0.1							0.2				0.1		0.6				2.3	W. 2.		
[a]	4.1 [a]	[a]1.3	[a]	[a]0.3	[a]	[a]	[a]	[a]	[a]		[a]		[a]	[a]	[a]		[a]5.0	[a]4.7			[a]36.1			[a]
	[a]	1.2		0.1		16.8		[b]12.1					[a]		[a]						0.2		[a]0.1	
			1.0			0.1					[a]0.2						0.1 20.2		[a]	[a]				
0.3	2.1	0.4	1.0	0.8		[a]2.3	2.0		0.4		3.1 [a]	[a]	[a]	2.9	21.6		0.4	0.4			0.4		3.4	3.2
[a] 0.5	[a] 8.3	[a] [a]	[a] [a]	[a] [a]		[a] [a]		[a]	[a] [a]		[a]		[a] [a]		0.3						[a] 2.2 6.3		[a] [a]	
		0.3									6.1						32.8	36.7	[a]2.5		0.1			
		0.4	0.2			0.3					[a]												0.1	
		0.2				1.5					2.6													
	0.4	[a]	0.2		[a]			[a]			2.0 5.7 [a]													
[a]	[a]	0.2 [a]	[a]0.1		[a]	1.3	[a]		[a]		[a]		[a]	0.1	0.1 [a]		5.5				[a]2.9		[a]	
0.8	14.9	1.8	2.4	1.3	[a]	22.3	2.0	12.1	0.4		19.2	[a]	[a]	3.1	22.1		64.5	41.8	2.5	[a]	50.6		3.6	3.2
[a]	[a]	0.9 [a]	12.7	11.0		[a]0.1 [a] 0.2		0.4	[a]	6.0		[a]	[a]		0.5	16.5	0.9	1.0	[a]	82.5	[a]3.6		7.9	4.0
		[a]				[a] [a]					[a]	[a] [a]									[a]0.1			
[a]	[a]	0.9	12.7	11.0		0.3		0.4	[a]	6.0	[a]	[a]	[a]		0.5	16.5	0.9	1.0	[a]	82.5	3.7		7.9	4.0
14.9	18.1	0.5	1.8	2.0	27.5	2.1	10.4	21.6	2.6	0.0	0.0	0.0	20.0	3.4	14.7	4.8	0.1	0.0	25.7	16.8	0.2		0.6	0.3
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	[b]100	[b]100	100	100	[b]100		100	100
1,190,000 M.T.	190,000 M.T.	297,000,000 M.T.	1,820,000 M.T.	1,796,000 M.T.	151,000 M.T.	7,700,000 M.T.	150,000 Flks.	120,000 M.T.	29,200 M.T.	173,000 M.T.	4,893,057 1000 bbls.	675,000 T.Oz.	5,500,000 M.T.	6,000,000 L.T.	1,575,000 M.T.	96,000 Lbs.	173,200 L.T.	178,800 L.T.	893,000 M.T.	47,000 MT.	55,400 M.T.	no total	2,522,000 M.T.	2,199,000 M.T.

Foreign Minerals Statistical Section
Region IX
Bureau of Mines
Department of Interior
October 1953

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denum might be a substitute for that very scarce material, tungsten. Of course there is more tungsten in the United States than you can use in the next 100 years if domestic producers could pay the same wages as are paid in southern China or in the Far East, where they pay practically no wages. However, we are dependent for tungsten on Spain, Portugal, and the Far East.

I will not say any more about tungsten, but I will say that the articles I read about it show utter ignorance of the facts. It is not confined to tungsten.

On this chart you have tin listed as a mineral for which we are partially dependent on foreign sources. You are entirely correct. Where does the tin in Bolivia go now?

Mr. ZINNER. I understand much of it goes to Great Britain.

Senator MALONE. And then comes back here to the principal market.

Mr. ZINNER. I think that is correct.

Senator MALONE. It crosses the ocean twice. So the tin cartel now has tin in the Western Hemisphere going to England to be refined and then to a large extent coming back here. The cartel also controls tin produced in the Malayan States. Therefore, the tin industry, as a whole, is controlled by the cartel.

Mr. ZINNER. I should say so.

Senator MALONE. For 20 years, an engineer working for the Government was taking his life in his hands to suggest a change. Is that not about right? I am speaking about his employment life, I will say.

Mr. ZINNER. I think that is true.

Senator MALONE. We hope it is changed now. We have an expert in tin?

Mr. ZINNER. That is right.

Senator MALONE. I will not go any further into tin at this moment.

I think, Mr. Zinner, you have made a fine witness. What is your preference in calling your own experts in the particular groups of these strategic and critical minerals and materials?

Mr. ZINNER. Mr. Melcher would be the first in the ferrous field to be followed by Mr. Johnson in the base metals field.

Senator MALONE. That is enough at this time. Unless you have a further statement you would like to make, you may call Mr. Melcher.

Mr. ZINNER. I would like to reserve the position, if I may, to supplement the statements that the commodity people make.

Senator MALONE. Speaking as the chairman of the committee, I will very much appreciate it if you would do just that to round out the testimony.

Mr. ZINNER. Thank you.

Senator MALONE. At this point in the record we will insert the two charts we have been discussing, and a chart entitled "Percentage Distribution, by Countries and Geographic Areas, of World Production of Selected Critical Metals and Minerals in 1952."

(The charts are herewith inserted.)

FERROUS AND FERROALLOY METALS

Senator MALONE. Mr. Melcher, will you come forward, please.

I want to say for the benefit of the record that I consider the testimony we are now about to receive on each of these groups of minerals

is the most important that has been received by any congressional committee in my experience in the Senate, and as far as I can remember, in my observation of congressional committees, as these witnesses are all experts in their respective fields. Mr. Melcher, will you identify yourself for the purpose of the record?

STATEMENT OF NORWOOD B. MELCHER, CHIEF, FERROUS METALS AND ALLOYS BRANCH, BUREAU OF MINES

Mr. MELCHER. I am Norwood B. Melcher, Chief, Ferrous Metals and Alloys Branch, Bureau of Mines.

Senator MALONE. Mr. Melcher, have you ever appeared before any congressional committee?

Mr. MELCHER. No, Mr. Chairman; this is a new experience for me.

Senator MALONE. It took another engineer to dig you out; is that it?

Mr. MELCHER. It could be.

Senator MALONE. I have known about you for a long time. You are familiar generally with the objectives of the committee to determine the availability of these strategic and critical minerals and materials and fuels to United States in time of war and for the expanding economy of the United States.

Mr. MELCHER. I believe so; yes.

Senator MALONE. Will you proceed with your statement?

Mr. MELCHER. Mr. Chairman, I have a brief prepared statement, if I may make it.

Senator MALONE. Go right ahead.

Mr. MELCHER. I am here to discuss iron and the ferroalloy metals. The latter group includes chromium, cobalt, manganese, molybdenum, nickel, tungsten, and vanadium. Of all these metals the United States is self-sufficient only in molybdenum and vanadium. Potentially the United States has reserves of iron and manganese that are sufficient to meet high level consumption rates, providing metallurgical processes are developed which will permit the use of low-grade materials.

This country could conceivably become self-sufficient in cobalt to meet modest peacetime requirements. For levels of high consumption, however, reserves even in the Western Hemisphere are not of adequate grade or quantity to permit production sufficient to meet our needs in the foreseeable future. This metal as well as chromium and tungsten comprise the three materials in the ferrous group for which at least partial dependence on foreign sources outside the hemisphere will be required to meet emergency needs.

Each of the ferrous metals has problems relating to supplies for the United States, and I would like to discuss briefly these commodities one by one.

IRON ORE

A basic problem with respect to iron-ore supply concerns the magnitude of requirements and prospective dependence upon nondomestic sources for as much as 35 percent of the total supply by 1970. Inasmuch as consideration must be given to costs in terms of manpower and equipment, even in emergency situations, it appears that this dependence is necessary until technology and economic conditions permit utilization of the lower grade domestic ores.

Senator MALONE. You are speaking now of the economic balance of costs which in an emergency might not be much of a factor.

Mr. MELCHER. Plus the technologic problems that we are working on.

Senator MALONE. Go right ahead.

Mr. MELCHER. Fortunately, a large proportion of the expected imports will come from Canada and most of the remainder from Venezuela. Adequate exploitation of our low-grade deposits is dependent upon field and laboratory investigations which will require a substantial period of years.

Senator MALONE. I do not want to interrupt your trend of thought, Mr. Melcher, but if it develops that the lines of transportation can be kept open in the Western Hemisphere, it is not too important for our national defense whether we get the ore in Canada, United States, Venezuela, or any other South American nation.

Mr. MELCHER. That is right. The tonnage obtained from overseas could probably be replaced by expanded production in this hemisphere.

Senator MALONE. In other words, we have no fear of our supply. We would be bolstering our economic structure if through laboratory experiments and investigation we did become more self-sufficient in the United States proper.

Mr. MELCHER. That is right.

Senator MALONE. Go ahead.

Mr. MELCHER. The time element will depend on the degree of effort expended. If we are to minimize dependency on foreign sources during the next 20 years, and if we are to be prepared for the time when Canada and Venezuela can no longer supply needed tonnages, an organized program of technologic investigation should be instituted immediately.

In contrast to iron ore, chromite is a material upon which the Western Hemisphere must rely on large imports from other sources.

Senator MALONE. Before you leave iron ore, is an investigation going on now in Brazil for iron ore?

Mr. MELCHER. There are large reserves of iron ore in Brazil; that is right.

Senator MALONE. Are there companies now organized and investigating these supplies?

Mr. MELCHER. Yes, but not on too active a basis.

Senator MALONE. If a normal investigation such as is generally conducted through the United States Geological Survey, were instigated by your Department, what ore reserves might be found in the Western Hemisphere?

Mr. MELCHER. There are large reserves of iron ore of various grades and several sources. Transportation is the big problem to developing them.

Senator MALONE. Your idea is that through laboratory work the lower-grade reserves in the United States could be used to bolster our own economy. But as far as national defense is concerned, while the transportation from South American nations and even from Canada would add to the cost of the ore, it would not retard our national defense if those lines of transportation could be kept open in time of war.

Mr. MELCHER. No, that is right.

Senator MALONE. That is the fundamental factor.

Mr. MELCHER. Yes, sir.

Senator MALONE. Continue, please.

CHROMITE

Mr. MELCHER. The Western Hemisphere consumes more than one-third of the current world production of 3½ million short tons per year.

Senator MALONE. That is chromite.

Mr. MELCHER. And it produces less than 3 percent. If it were possible to satisfy all Western Hemisphere chromite requirements from currently commercial reserves, including commercially acceptable ores, that is by industry, mined at subsidy prices, the reserves would be depleted in 1 year.

Senator MALONE. You are talking now about the known reserves.

Mr. MELCHER. Yes, sir; known commercial reserves.

Senator MALONE. You heard Mr. Zinner discuss the word "commercial." What foreign nations are chief sources of the various grades of chromite?

Mr. MELCHER. There are three grades of chromite. The metallurgical, refractory, and chemical grades. Turkey and Southern Rhodesia are the main sources of metallurgical, South Africa is our main source of chemical, and the Philippines the main source of refractory grade.

Senator MALONE. The existence of chromite deposits of lower grade in Oregon and Montana is well known. A mill costing $25 million was built in Montana, but immediately after the war and before anybody could turn around, some great organization authorizes its destruction. Perhaps the true facts will never be known, but have they completed the new mill for Montana chrome?

Mr. MELCHER. They are now in production. I think they are still doing some work on the mill.

Senator MALONE. What is the capacity?

Mr. MELCHER. The capacity is to produce, as I recall, 100,000 tons of concentrates per year, treating 1,000 tons of ore a day.

Senator MALONE. A thousand tons of ore per day?

Mr. MELCHER. 1,000 tons mill.

Senator MALONE. The mill treats low-grade ore?

Mr. MELCHER. That is right.

Senator MALONE. You get 100,000 tons of concentrate per year?

Mr. MELCHER. Yes, sir.

Senator MALONE. What would be the percentage?

Mr. MELCHER. Well, they will run 36 to 38 percent of chrome oxide.

Senator MALONE. What grade? You say there are three grades of chromite. In which category is this chrome in Montana?

Mr. MELCHER. The main use would be metallurgical. We in the Bureau are doing research in all three categories on the possible use of these materials for refractory and chemical. We had very little luck with substituting it for chemical uses.

Senator MALONE. So far.

Mr. MELCHER. That is right.

Senator MALONE. But you have hopes?

Mr. MELCHER. We have not given up yet.

Senator MALONE. You are an expert in this chrome field, and I am not an expert, but I have observed a lot of chromite mining in the States containing these known deposits. What are the types of deposits in which this material is found?

Mr. MELCHER. In this country in general there are two different types. Chromite is found associated with serpentine. It exists in two categories, the large vein material, and what we call kidney or pod deposits. Those are frequently of higher grade than the larger vein type deposits.

Senator MALONE. Let me ask you this question, Mr. Melcher. If these kidneys or pods are not found isolated, would there be any connection between one pod or another, except that you would know that you are in a chrome area?

Mr. MELCHER. That is frequently the case.

Senator MALONE. There is no reason why you should find another kidney except you nearly always do if you keep developing.

Mr. MELCHER. That is about the case historically.

Senator MALONE. In other words, in my work with the Senate Military Affairs Committee, and I was also consultant to the Secretary of War during World War II, I studied this chrome production, and there was more chromite in reserves at the end of the war than there was at the beginning, because it had become profitable to mine during the war.

Mr. MELCHER. It is largely related to the rate of production possible from that type of deposit. It is difficult to project future discoveries, except on the historical rate in the past.

Senator MALONE. In other words, there will be no new discoveries at all unless it is profitable to mine it?

Mr. MELCHER. That is certainly reasonable.

Senator MALONE. It comes to the same basic problem you heard outlined by the Assistant Secretary of the Interior yesterday, if it is a profitable venture when you are only competing with your own standard of living wages and domestic cost of material, then you are in business. If you are made to compete with the lower-cost labor countries on an even basis, you are out of business. Is that about the way it runs?

Mr. MELCHER. In chromite it is certainly true. It requires a substantial price.

Senator MALONE. Yes. For example, the chairman of this committee, at this very table, provided for the extension of the purchase of chromite for 2 years, simply because there was no way of evening the competition between American producers, and we will say South African producers. They pay what we would call no wages at all maybe 50 cents a day up to $2 a day. The standard-of-living wages are $12 to $15 a day for labor in this country. Therefore miners are never in business unless the Congress sees fit to establish a purchase program which will allow them to pay the standard-of-living wages in this country, or unless some principle is established, as your Assistant Secretary of Interior described yesterday, of direct subsidies, or quotas which will not allow the competitive product to come in to compete with our production, or unless a duty such as the Constitution provides is levied by Congress. The chairman does not believe in the special-bill method, but in order to enable domestic chromite producers to stay in business, he was forced to employ this method in the past. In other words, unless one of these methods is put into operation, our mines are out of business. Is that correct?

Mr. MELCHER. That is right. The reserves classified as commercial in the case of chrome are based on the price at the purchase depot.

Senator MALONE. What is the price now under what might be called the Malone bill?

Mr. MELCHER. That is $115 per ton.

Senator MALONE. And they are in business now?

Mr. MELCHER. They are in business.

Senator MALONE. But they are only in business for a couple of years.

Mr. MELCHER. Until 1957.

Senator MALONE. Say 3 or 4 years. But under those special conditions which are always subject to a congressional act or the decision of some bureau official who may not know a pound of chrome from a bale of hay, will private investors go into the business to the extent they would if a long-range principle was laid down?

Mr. MELCHER. They certainly will not make long-range investments on that basis.

Senator MALONE. In the mining business, knowing it as you do, and I know you do know it, is it not a long-range industry?

Mr. MELCHER. That is the historical pattern.

Senator MALONE. In other words, if you and I are correct in describing deposits of chromite as pods or kidneys with no connection with each other except that the area is a known chromite area, there is no reason why you should find another pod or kidney except you know you always have when you kept digging.

Mr. MELCHER. Within limits; yes.

Senator MALONE. Within limits of the known area, but you cannot drill and determine these pods and kidneys for an entire area.

Mr. MELCHER. It is very difficult and uneconomic.

Senator MALONE. Do you not have to depend on the miners? I have described a miner's life as a disease. These old miners will not do anything else. I remember during World War II somebody had the idea that if they stopped gold mining all those gold miners would be available for the mining of chromite. You are familiar with the fact that none of them did mine anything else.

Mr. MELCHER. That is right.

Senator MALONE. So when you shut a chromite mine, a chromite miner does not go to mining tungsten. He does not know anything about it.

Mr. MELCHER. We have some miners that are quite versatile.

Senator MALONE. Is it not a fact generally speaking that zinc and lead miners, and tungsten miners, and chromite miners, and gold miners, have spent their lives or a good part of it in their particular field, and they do not go anyplace else? Is that right?

Mr. MELCHER. Yes.

Senator MALONE. It seems to me to be similar to the solution suggested when steel was so scarce during World War II. Somebody inquired whether it would not be feasible to save steel by taking the shoes off the horses at night.

Mr. MELCHER. When they do not need them.

Senator MALONE. And put them back on in the morning and save the night wear and tear on the steel. Isn't it about the same kind of request, as a request for a miner to move to another mineral in which he is not experienced?

Mr. MELCHER. In general, I think that is correct.

Senator MALONE. Generally speaking, to produce the maximum amount of chromite in this Nation, you would have to lay down a long-range principle, whether it was a 20-year subsidy program or a 10- to 20-year program of levying duties, imposts, excises, or tariffs, to alleviate the difference between the wage standard of living between here and abroad.

Mr. MELCHER. That is true.

Senator MALONE. You would have to adopt one of them. However, any principle laid down by one Congress can always be nullified by another Congress. So the subsidy programs sometimes is like skating on thin ice.

Mr. MELCHER. I am not a lawyer, but I think that is true.

Senator MALONE. You are a practical man. You are in the mining business. Do you think it wears pretty thin?

Mr. MELCHER. Congress can change it at any time.

Senator MALONE. You go right ahead with your statement.

Mr. MELCHER. The Bureau of Mines and industry have cooperated to demonstrate that low-grade ores, such as occur in Montana, can be utilized for many purposes. Research in this important field should be continued. Of the 300 million tons of contained Cr_2O_3 estimated to represent the world's resources of chromium, the iron ores of Cuba account for about 17 percent. It is evident that mining and metallurgical research aimed at the full utilization of these ores would free the Western Hemisphere from its dependence on foreign chrome sources for close to half a century.

Senator MALONE. Right at that point, I think that is a very important statement, because in your chart "Partial Dependence on Foreign Sources" under "Potential, Western Hemisphere," chromite is listed. You think it would be taken out of that category entirely if you followed through on a logical investigative program?

Mr. MELCHER. That is right. We can lick the Cuban problem and have plenty of chrome there.

Senator MALONE. You have no doubt about being able to lick it if we gave you a couple of dollars to do it?

Mr. MELCHER. Not at all.

Senator MALONE. Then it is up to Congress to decide whether they want to do it or not?

Mr. MELCHER. That certainly takes money to do it.

Senator MALONE. Let us estimate about how much money it would take annually for the next 2 or 3 years to bring that about, just for that one metal.

Mr. MELCHER. We are spending currently something like $200,000 a year on that program.

Mr. ZINNER. May I interrupt at that point?

Senator MALONE. Yes.

Mr. ZINNER. I think it is fair to point out that this chrome occurs with other commodities. We are attacking the laterite problem from the nickel side of it at the present moment, but it also contains chromium, cobalt, and iron. You cannot approach this chrome program solely on the basis of chrome from the laterite, but it has to be approached on all the commodities. It will be a coproduct or byproduct of whatever commodity you are after.

Senator MALONE. Does not that statement apply to many other ores? Your ilmenite occurs with iron.

Mr. ZINNER. That is true. But it is particularly true with the laterites, because it is a tough separation problem and a relatively low material.

Senator MALONE. You would call it complex ores. You have to lick the separation.

Mr. ZINNER. That is right.

Senator MALONE. Did we not have a complex ore problem in the production of zinc and lead in southern Nevada for some 25 years before you whipped it?

Mr. ZINNER. Very much so.

Senator MALONE. Now it is whipped.

Mr. ZINNER. That is right.

Senator MALONE. And some of the largest production is coming from those complex ore bodies of zinc and lead. So it comes back to what Mr. Melcher has said, if we want to whip the problem, it will cost us a few dollars to do it. It is a question of what Congress wants to do about it.

Mr. MELCHER. It is a very valuable resource.

Senator MALONE. Let me say to you, speaking from personal observation and experience during World War II, for the first 6 or 8 months of the war, the German submarines were sinking 88 to 90 percent of our ships carrying chromite and manganese from South Africa. Did you happen to be connected with the Bureau at that time?

Mr. MELCHER. I did not have those figures, but I knew there were substantial losses.

Senator MALONE. We could have lost the war if we had not overcome the submarine menace within a reasonable time. Do you think the $200,000 a year for 2 or 3 years would be worth saving 88 percent of the ships from South Africa in case of another war, to say nothing of the loss of life and ships?

Mr. MELCHER. I think it is worth a lot more than that.

Senator MALONE. If we were to compute the cost of our shortsighted policy in loss of life and ships to every ton of chromite we received out of South Africa during the first 6 months of the war, it probably cost us many thousands of dollars per ton.

Mr. MELCHER. It certainly cost a lot of money.

Senator MALONE. So you will be asked by this committee—I am warning you now—to estimate what this program would cost to carry it through to completion. Go right ahead.

COBALT

Mr. MELCHER. In the case of cobalt, metallurgical extraction methods rather than inadequate reserves have largely prevented the Western Hemisphere from becoming self-sufficient in the production of this strategic metal.

Senator MALONE. And that is one of the metals that is listed in partial dependence on foreign sources outside the Western Hemisphere in the last column of your sheet No. 2 submitted for the record.

Mr. MELCHER. That is right. I repeat that cobalt is also an important constituent of the Cuban laterites.

Despite the large potential reserves of cobalt in the Western Hemisphere, virtually all of the cobalt is found associated with other metals and seldom does it occur in sufficient quantity to be mined for cobalt

alone. Moreover many of the deposits do not contain cobalt in sufficient quantity to make recovery economical. Few metals exhibit in their processing from ore to refined metal need for such diversity of metallurgical operations as does cobalt. Frequently it is a laborious and time-consuming task to develop metallurgical processes adapted to the commercial recovery of cobalt. Provided processes develop for extracting cobalt contained in the ores of Cobalt, Idaho, and Fredericktown, Mo., attain scheduled production rates, the United States will have capacity to produce cobalt at an annual rate of 5,300,000 pounds, which is greater than consumption in any year previous to 1950. However, this anticipated production plus that from Canada, would fall far short of meeting mobilizaiton requirements for the United States.

Senator MALONE. This is in case of an all-out world war IV.

Mr. MELCHER. Yes, sir.

Senator MALONE. Before we leave cobalt, is it a difficult material to stockpile?

Mr. MELCHER. No, not particularly.

Senator MALONE. In other words, it does not deteriorate in a stockpile?

Mr. MELCHER. No.

Senator MALONE. Then it would be very logical that we should build a stockpile in addition to our all-out production in the Western Hemisphere to enable us to efficiently wage any foreseeable war?

Mr. MELCHER. There is stockpiling going on which, of course, is aimed at that objective.

Senator MALONE. We brought out several interesting features in the stockpile which we hope to correct. One feature we discovered was that any metal which is being stockpiled can be used to break the domestic market through an Executive order. As a matter of fact, Congressman Martin, who will be here at 1 o'clock, will present testimony which will be very interesting in that regard. In other words, an emergency was declared in one or more instances for what was really a political emergency.

Mr. MELCHER. For the removal of materials from the stockpile.

Senator MALONE. Yes, to stop a bill that was before the committee at one time. I will leave that to Mr. Martin.

Mr. MELCHER. Shall I proceed?

Senator MALONE. Yes.

MANGANESE

Mr. MELCHER. Manganese consumed by the United States is obtained largely from foreign sources. Most of this manganese comes as ore over long sea routes from beyond the Western Hemisphere, but Brazil's contribution may be expected to increase materially. The United States does have large natural deposits of low-grade refractory materials besides a large potential source of supply in the form of open-hearth slags. Work of the Bureau of Mines in cooperation with private industry to develop satisfactory methods for recovering manganese from slags has progressed to a point where pilot plants have shown recovery to be technically feasible.

Much work yet remains to be done in the way of large-scale operations in order to make these various sources a reliable and quickly obtainable reserve in time of emergency.

I might say that one private firm has undertaken this project on a small commercial size operation. It is under construction at the present time.

Senator MALONE. As I understand this, Mr. Melcher, and I am generally familiar with the work of your Bureau and the results, it is now believed by your Bureau and this one commercial producer that through a process largely perfected by your Bureau the manganese in the steel slag dumps can be worked profitably. I am given to understand that maybe 75 to 90 percent of the manganese contained in the slag dumps is recovered. Is that correct?

Mr. MELCHER. Ninety percent is recovered? That is too high. The open hearth slags produced approximately half of the production which has historically been used to add manganese to blast furnaces. So only about half of the production would be available for this process. We estimate somewhere between 25 and 50 percent of our needs could be obtained from this source.

Senator MALONE. I understand that. For the record what is the particular function of manganese in steel?

Mr. MELCHER. Manganese is added to steel for three purposes. One is the scavenger agent.

Senator MALONE. It removes what?

Mr. MELCHER. Oxygen and sulfur.

Senator MALONE. It removes the materials that weaken steel.

Mr. MELCHER. That is right. Manganese is also left in the steel to combine with residual sulfur in the steel and renders it relatively harmless in the finished steel.

Senator MALONE. It renders the sulfur content relatively harmless.

Mr. MELCHER. That is right. Manganese added to steel grasps the sulfur and forms manganese sulfides which do not have the harmful effects that iron sulfides do in steel.

Senator MALONE. And then it cleanses the steel of certain other harmful products?

Mr. MELCHER. That is right. The third use would be as an alloying element for its own properties.

Senator MALONE. Generally speaking, what amount of manganese—ferromanganese or liquid manganese or whatever might be used that is added to steel—finds its way into the slag dumps?

Mr. MELCHER. Approximately one-half of the manganese added as ferromanganese goes into the slag dumps. That is expanded or increased by other manganese that is added to the steel furnaces mainly from iron ores.

Senator MALONE. In other words, the natural content of iron ore.

Mr. MELCHER. That is right.

Senator MALONE. On the average, how many pounds of manganese are utilized in the manufacture of a ton of steel? Of course, that would vary in grades of steel. You might give us the variation and then the average.

Mr. MELCHER. It varies widely, but the average is about 14 pounds of manganese added to a steel bath.

Senator MALONE. I used to quote 12 to 14 pounds, but the average is about 14?

Mr. MELCHER. Yes.

Senator MALONE. How high would it run in tool steel or the highest grade steels?

Mr. MELCHER. Some manganese steels of the famous types contain 13 percent more manganese content.

Senator MALONE. What would that run in pounds?

Mr. MELCHER. A 2,000-pound ton would be 250 to 260 pounds.

Senator MALONE. That would be the highest grade steel?

Mr. MELCHER. There might be a few that would run somewhat higher. But that is the main tonnage of what we call high-manganese steel.

Senator MALONE. What would be the lowest use per ton of steel?

Mr. MELCHER. I have no actual data on that, but I presume it would run in any steel over 10 or 12 pounds.

Senator MALONE. Of course, that is a rather loose way to use the term because there are very low grade steels.

Mr. MELCHER. That is just my impression.

Senator MALONE. You do not think any of it would run less than 10 pounds?

Mr. MELCHER. I would not think there would be any less than that.

Senator MALONE. Of course, there is a very great tonnage of the lower grade steel as against the relatively small tonnage of the tool steel and high-grade steel.

Mr. MELCHER. That is very small relatively.

Senator MALONE. That is the reason that the average is 14 pounds.

Mr. MELCHER. That average is very close to the minimum; yes, sir.

Senator MALONE. About what percentage of this manganese that is used finds its way into the slag dump?

Mr. MELCHER. About half.

Senator MALONE. About 50 percent, taking all grades, roughly?

Mr. MELCHER. Yes.

Senator MALONE. And it is the slag dump manganese that can be recovered, then. That can be recovered through the new process that the Bureau of Mines has developed?

Mr. MELCHER. That is correct, with the qualification that up until the present this process was not anticipated and much of the earlier slag production has been lost as far as any recovery is concerned.

Senator MALONE. A large amount of these old-time slag dumps are available in sufficient quantity to warrant construction of a plant?

Mr. MELCHER. Yes, but they have been contaminated by other dumps and refuse, and much of it has been used for fill.

Senator MALONE. Roadmaking, and so forth.

Mr. MELCHER. Yes.

Senator MALONE. And it is gone.

Mr. MELCHER. In fact, the problem was to get rid of it in the old days.

Senator MALONE. That is true. Have you made any estimate of the number of slag dumps or the tonnage that might be available for processing?

Mr. MELCHER. No; we have made most of our assumptions that industry taking up this process would use current production of slag, rather than go back and try to develop the old slag dumps. Some of the companies, however, in anticipation of this have separated out the higher manganese slag and have kept it in reserve.

Senator MALONE. Fifty percent of this manganese goes into the dump. It has been estimated that there is a large tonnage in existing dumps that might be available. We will defer discussion on that

situation and concern ourselves with current production of slag. Each of these large steel companies would make their recovery from the 50 percent of manganese going into the slag dumps. What percentage of that 50 percent can be recovered?

Mr. MELCHER. Around 70 percent.

Senator MALONE. That is what I had in mind when I said 75 to 90 percent. I had been given to understand that the recovery is rather high.

Mr. MELCHER. It might be somewhat better than that, but I would not bet on it.

Senator MALONE. Suppose 50 percent finds its way into the dump and we recover 70 percent of it. That would be a recovery of roughly 35 percent of the manganese that could be used over and over again.

Mr. MELCHER. Yes, sir.

Senator MALONE. If carried to its logical conclusion, it would cut new manganese production about 30 percent.

Mr. MELCHER. That is in the approximate range, yes.

Senator MALONE. That, in your opinion, is a lot of progress; is it not?

Mr. MELCHER. I think it is.

Senator MALONE. Especially since we have become dependent on foreign shores across the oceans for a large amount of our consumption.

Mr. MELCHER. Yes, sir.

Senator MALONE. Unnecessarily so, as many of us believe. But as someone said yesterday to me—it was a Cabinet officer, by the way, who I thought was very charitable—in a very well-put phrase. He said because we can do something today and we did it differently a few years ago does not mean we made a mistake then, but that existing procedures were followed. Therefore, the waste of this manganese in the past was not a mistake. There was no known method of saving it.

Mr. MELCHER. That is right.

Senator MALONE. But now we do have a way of saving it. We are talking about national defense and our economic structure. In your opinion, with the South American explorations that are going on, and I am given to understand United States Steel—and we will hear United States Steel representatives before we are through—is finding a great amount of manganese in Brazil.

Mr. MELCHER. They have important reserves there.

Senator MALONE. So in your opinion if these things are carried to a logical conclusion, we can become self-sufficient in the production of manganese for this Nation in the Western Hemisphere.

Mr. MELCHER. Yes, sir.

Senator MALONE. And a much greater amount can be produced in the United States than is currently being produced.

Mr. MELCHER. That is correct.

Senator MALONE. Go right ahead.

MOLYBDENUM

Mr. MELCHER. The free world supply of molybdenum is virtually all obtained from the Western Hemisphere. Plant expansion in the United States now nearly completed will provide a productive capacity larger than that needed to provide for the domestic and export requirements except in periods of all-out emergency. The surplus production

being stockpiled by the Government will provide materials needed for any sudden emergency. Ore reserves are ample for long-term production.

Senator MALONE. Where is that production located?

Mr. MELCHER. The production of molybdenum as such comes from Climax, Colo.

Senator MALONE. It is mostly a Colorado production.

Mr. MELCHER. It is about half and half between that and the molybdenum produced as a byproduct of copper production.

Senator MALONE. Where is that produced?

Mr. MELCHER. That is largely Utah, Arizona, and New Mexico.

Senator MALONE. It is all in the United States?

Mr. MELCHER. Yes, sir.

Senator MALONE. Has there been any indication in South America or Canada of molybdenum or has any real search or investigation been made?

Mr. MELCHER. No indications of any large production.

Senator MALONE. Investigation has not been necessary in this field because, according to your testimony, we are supplying almost the entire world?

Mr. MELCHER. That is correct.

Senator MALONE. And have ample supplies in the foreseeable future?

Mr. MELCHER. Large reserves.

Senator MALONE. Thank you. Go ahead.

NICKEL

Mr. MELCHER. Underlying the nickel-supply problem of the United States is the great disparity between peace and war requirements. The industry geared to peacetime requirement is entirely inadequate to meet war needs. On the other hand, an industry expanded to supply war demands would find itself with an enormous burden of excess capacity when peace was reestablished. The presently equipped deposits of nickel ore in the Western Hemisphere can supply the peacetime requirements of the United States. Expansion programs now underway in the United States and Canada will result in an annual capacity of about 200,000 tons of nickel by 1956.

Senator MALONE. Annual production?

Mr. MELCHER. Yes, sir.

Senator MALONE. And that is nickel metal?

Mr. MELCHER. As nickel metal. The Cuban deposits appear to offer the best opportunity to further expand the supply of nickel. However, until a process is developed to recover the associated metals of cobalt, chromium, and iron, production costs will be substantially higher than in Canada.

Senator MALONE. That is, if the ore is mined and milled for the nickel alone, the costs would be substantially higher than in Canada?

Mr. MELCHER. That is the case at the present time.

Senator MALONE. Are you encouraged in your investigations to separate the associated metals of chromium and cobalt and what other metal?

Mr. MELCHER. We are encouraged.

Senator MALONE. What other metal?

Mr. MELCHER. Cobalt, chromium, nickel, and iron.

Senator MALONE. Cobalt, chromium, and nickel are all three strategic.

Mr. MELCHER. Very much so.

Senator MALONE. Do you think that in the near future your laboratory experiments and investigations will bear fruit, and that you will be able to recover the minerals?

Mr. MELCHER. That is what we are working on. We have considerable encouragement already. We have been working on this for some time, but on a greatly expanded scale at the moment.

Senator MALONE. I am very happy to have the opportunity to bring out what your Bureau is really doing. I think only men like you who are actually conducting these experiments can make this information available. Certainly no one ever has before.

Mr. MELCHER. We certainly are glad to inform you.

Senator MALONE. Is nickel a metal that can be stockpiled without deterioration?

Mr. MELCHER. Yes, sir; it can.

Senator MALONE. In your opinion, is there any reason why within a very reasonable time the United States, Canada, Cuba, and the nations of the Western Hemisphere, very close geographically to the United States, could not be self-sufficient, including a proper stockpile for any foreseeable emergency?

Mr. MELCHER. We are always hesitant to forecast the results of our research, particularly on an economic basis. I certainly have every confidence that it will not be too long.

Senator MALONE. By an economic basis, you mean commercially competitive?

Mr. MELCHER. I believe the Cuban deposits can be made commercially competitive.

Senator MALONE. But anticipating a war and the needs of the stockpile, that would not necessarily be the controlling factor, would it?

Mr. MELCHER. No. Our more immediate program is to find ways of doing it regardless of cost.

Senator MALONE. And you think that will be accomplished within a reasonable time?

Mr. MELCHER. On nickel much headway is being made. We are having more difficulty in cobalt and chromium.

Senator MALONE. But you see no insurmountable obstacles, if you are allowed to proceed with your investigations?

Mr. MELCHER. I do not see any; no.

Senator MALONE. That will be a judgment of the Appropriations Committees of Congress, will it not?

Mr. MELCHER. We would like to expand that work; yes, sir.

Senator MALONE. I want you to understand that you will be asked in each area of minerals wherever a situation arises such as you are describing to estimate for the committee what would be necessary to carry to a logical conclusion your investigations now under way. Go ahead.

Mr. MELCHER. Along the same line, the Bureau of Mines is conducting metallurgical studies to develop and improve a lower-cost method of extraction of nickel from Cuban laterite and serpentine, and for recovering the associated cobalt, chromium, and iron. If all of these valuable constituents could be recovered, the gross value

of the ore would be about $24 a short ton. Thus, there is quite a bit of latitude for research.

Senator MALONE. Roughly, without being pinned to any estimate at all, but for the benefit of the committee, if you are able to separate these materials, which would be valued at $24 a short ton, what would be your estimate as to the cost of treating these ores per ton on a volume basis?

Mr. MELCHER. I would say it is impossible to estimate this early.

Senator MALONE. It would be well within the value——

Mr. MELCHER. I am giving the figure as an indication of a ceiling under which we have to work; $24 is quite a valuable ore.

Senator MALONE. In other words, your general opinion would be that considering the commercial value of cobalt, nickel, and chromite, that $24 ore could be worked profitably if you develop a successful process of separating.

Mr. MELCHER. That is right.

Senator MALONE. You think it could be worked within that range?

Mr. MELCHER. I am just pointing out that $24 is a fairly high figure to be able to work under. We must find processes first, and secondly to gradually lower the cost of those processes to stay within that ceiling. That is the long-range program on this ore.

Senator MALONE. That $24 is based upon the present commercial value of those ores?

Mr. MELCHER. That is right.

Senator MALONE. And if we needed them for war purposes, the present commercial value would not necessarily be the deciding factor?

Mr. MELCHER. That is right.

Senator MALONE. Go ahead. Anyway, we are in shooting distance of our Western Hemisphere where we have reasonable basis for believing we can keep our transportation lines open.

Mr. MELCHER. It is right in our backyard.

Senator MALONE. Go ahead.

TUNGSTEN

Mr. MELCHER. On tungsten, the present prices of concentrates have extended ore reserves and have led to production that makes the United States virtually self-sufficient in terms of present requirements. However, the United States production is only three-fourths of the peak of World War II and one-half of the wartime consumption rate.

Senator MALONE. Right at that point, is there anything in the nature of tungsten ore which would cause it to deteriorate in a stockpile?

Mr. MELCHER. No.

Senator MALONE. It would be a question, then, of judgment as to what size stockpile would be necessary, taking into consideration domestic production, to meet consumption in this country in case of an all-out emergency?

Mr. MELCHER. That is right.

Senator MALONE. You are aware that it is only by a special bill, the bill I previously referred to, which extended the purchase program for tungsten, that the tungsten miners are in business now.

Mr. MELCHER. That is right.

Senator MALONE. In other words, with the direct competition of Burma and southern China always a threat to private investment, very little private money would be put into the development of tungsten, without some special legislation, is that not correct?

Mr. MELCHER. Yes; except at least in the higher cost production, sir.

Senator MALONE. The higher cost production is brought about by our high wage living standard, is it not?

Mr. MELCHER. Also as I pointed out, it extends the reserves. At higher levels we can work lower grade ores.

Senator MALONE. Are there more reserves of tungsten available right now, than there were before World War I when everybody thought we were out of tungsten?

Mr. MELCHER. I do not have the figures right here, but present reserves would not be very different.

Senator MALONE. We always have reserves if it is a profitable enterprise. Is that the history of mining generally in this country?

Mr. MELCHER. That is generally true.

Senator MALONE. So when they talk about every nation producing what they can produce, they are talking the wage standard of living and lack of the security of the workers in other nations.

Mr. MELCHER. To some degree, and also the price governs the reserves.

Senator MALONE. Of course it does. I am speaking of $15 a day wages in the United States as compared to 40 cents a day in Burma, where machinery paid for by American taxpayers is being used. We then begin to look at the subject cold-bloodedly as to what we mean by another nation producing what we need. Burma is a long way from here, is it not?

Mr. MELCHER. It certainly is.

Senator MALONE. It is farther away than the domestic sources of tungsten in this country.

Mr. MELCHER. They are right at hand, and we have substantial reserves of the lower grade material.

Senator MALONE. I hope you are asked to collaborate in the next article in the Wall Street Journal about the very scarce tungsten. The Wall Street Journal is a great paper. This is no criticism of the Wall Street Journal. It is a criticism of the people who are running these programs and giving them this information. The Journal has accurate reporters. According to the information which has been given out for 20 years in this last administration, their article is entirely correct.

Mr. MELCHER. Of course, reserves do not last forever.

Senator MALONE. But let us go back to those reserves. How do you find reserves? By making it unprofitable to mine or by making it profitable to mine?

Mr. MELCHER. Profitable, of course.

Senator MALONE. Do you know of any going-concern mining industry that ever has any more than 2 or 3 years reserves ahead?

Mr. MELCHER. In some cases somewhat more than that, but that is a good reserve.

Senator MALONE. If the reserves are more than 2- or 3-year reserves, it probably is to the accidental discovery of a very rich area. What country could afford to have more than 2 or 3 or 4 years of reserves? Do you know of any?

Mr. MELCHER. No. That is the point. It is related to the price and profit.

Senator MALONE. That is what you call a going-concern mining industry, is it not?

Mr. MELCHER. That is right.

Senator MALONE. For 20 years we were told we must keep our minerals in the ground, and if you keep them in the ground, you do not know where the reserves are and you lose your miners, do you not?

Mr. MELCHER. I believe we should be in production of these commodities.

Senator MALONE. It is the only way that you can keep yourself in position to speed up a mining operation in time of emergency. Is that correct?

Mr. MELCHER. Yes.

Senator MALONE. I would like to say at this point—and I am not asking you the direct question because you are working for the Government, and a little bit handicapped in making a free statement—that the policy for the past 20 years of saving materials by keeping them under ground and thereby losing your experienced miners and keeping young men from going into the business because of the lack of stability, has insulted the intelligence of every mining producer and every consulting engineer in the United States of America. I think I can say that without fear of contradiction. I will not ask you to agree with it.

Mr. MELCHER. Thank you.

Senator MALONE. But you are a practical man.

Mr. MELCHER. From the long-term standpoint the known tungsten ore reserves of the Western Hemisphere are not large enough to maintain the present rate for an extended period.

Senator MALONE. What metal is this?

Mr. MELCHER. Tungsten. However, exploration and development of tungsten deposits was at a virtual standstill during the period from the end of World War II up to the Korean emergency, and exploration and development now under way may disclose new ore deposits at a rate faster than known ores are mined.

Senator MALONE. Let us have another look at that reserve. Do you know of any mining company that could just explore indefinitely without mining?

Mr. MELCHER. No.

Senator MALONE. Do you know any that have over 3 or 4 or 5 years of reserves?

Mr. MELCHER. That just explore and not mine?

Senator MALONE. Yes.

Mr. MELCHER. No.

Senator MALONE. Now, such reserves are impossible under a competitive system of mining with private capital. Is that correct?

Mr. MELCHER. Of course, assistance now is possible by Government to permit exploration.

Senator MALONE. Taxpayers' money.

Mr. MELCHER. Yes.

Senator MALONE. In other words, you can take taxpayers' money and just keep on exploring, but is it necessary if you have a going-concern mining industry made possible by conditions established by Congress?

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Mr. MELCHER. It is an attempt to stimulate expanded production.

Senator MALONE. It is just a long-range policy by Congress that if a man finds half of 1 percent of tungsten ore and the vein has any depth or width, he is in business.

Mr. MELCHER. That is a good grade of tungsten nowadays.

Senator MALONE. That is right. Let me compare it to something else. You talk about reserves. Your United States Geological Survey, which is one of the finest organizations in the world in my humble opinion, said in 1925 that the limit of our oil production was 5 billion barrels. That was all there was in this country. It scared everybody to death. Then we had a Secretary of Interior about 18 years ago who said the same thing, except he raised the limit a little. In my opinion, all you ever had to do was to turn the oil companies loose. You know we now have 32 billion barrels of reserve, and with the importation of oil, it is now running out of our ears. Thompson of Texas is complaining to high heaven that Texas oil wells are closing. So if you adopt a policy which does not allow private capital to go ahead and develop reserves, you will eventually run out of reserves, wouldn't you?

Mr. MELCHER. That certainly is true in tungsten.

Senator MALONE. It is true in oil. Is it not true in every metal?

Mr. MELCHER. As far as I know.

Senator MALONE. You are bound to run out of metals when you make it impossible to mine them?

Mr. MELCHER. If you cannot make any money.

Senator MALONE. You would finally arrive at the point that the State Department for 20 years has said we were in. They can make their program successful. We could be entirely out of ores and unable to defend ourselves in case of war.

Mr. MELCHER. Mr. Zinner just pointed to the fact that tungsten reserves on this new chart are larger than they were on the one we provided several years ago.

Senator MALONE. And when you make a chart next year, if tungsten mining is a profitable operation, it will be still larger. Is that a logical conclusion?

Mr. MELCHER. Yes. I pointed out that there is plenty of room for expanding those reserves.

Senator MALONE. But if we do all the mining from Washington and make it unprofitable to mine, you could run out of reserves.

Mr. MELCHER. If you have no profit, you have no reserves.

Senator MALONE. And if you have a profit, you have all the reserves you want in tnugsten.

Mr. MELCHER. Within certain limits.

Senator MALONE. What are the limits? We mined all the tungsten we needed in this United States of America at the peak of World War II.

Mr. MELCHER. Only limits to continued production at the current level or attempting to meet wartime needs, then they would become depleted.

Senator MALONE. The known reserves would become depleted. Do we not have more tungsten reserves at the present time than we had at the beginning of World War II?

Mr. MELCHER. Yes.

Senator MALONE. And did we not produce an enormous amount of tungsten during World War II? Did we not produce all we needed for a while?

Mr. MELCHER. I do not remember that we got in that favorable position.

Senator MALONE. We had a greater amount of tungsten production in the United States and the Western Hemisphere than our consumption in any one of 4 or 5 years according to your chart.

Mr. MELCHER. Yes. Here is a table along that line; 1943 was a peak production year.

Senator MALONE. And also a peak consumption. From the Western Hemisphere, and United States production we had more production than tungsten consumption.

Mr. MELCHER. I am sorry, I thought you said the United States alone.

Senator MALONE. In certain years we had a production in United States equal to consumption.

Mr. MELCHER. Not during the war.

Senator MALONE. Tungsten has been unprofitable to mine in almost every case since 1934, except through special bills by Congress providing for a purchase program.

Mr. MELCHER. In many cases. Yes, sir.

Senator MALONE. Because you had absolute competition from nations paying labor from 40 cents a day up to $2 a day, and therefore no private money would go into domestic production, would it?

Mr. MELCHER. It was very difficult.

Senator MALONE. That is nobody in their right mind.

Mr. MELCHER. Yes, sir.

Senator MALONE. A miner who has the mining disease has never been in his right mind. He would just keep on losing his money and insisting he is going to mine whatever metal happens to be his business. But we are running out of those old hedgehogs and we are not developing any new ones. Unless we have a long-range policy laid down by Congress the young men will not go into the mining industry.

Mr. MELCHER. We need a lot of incentive for young men to enter the industry.

Senator MALONE. I want to point out to you right here that the chart prepared in your office shows that $63 or $65 price established for tungsten, actually amounts to about a $40 price when adjusted to the wholesale commodity index price.

Mr. MELCHER. That is probably about right.

Senator MALONE. That is right. We have already computed it.

Mr. MELCHER. Yes.

Senator MALONE. So what would have been a high price 10 years ago, right now is not a very high price for tungsten.

Mr. MELCHER. And it has doubled our production.

Senator MALONE. And it has doubled our production. That is right. Go ahead.

Mr. MELCHER. Mr. Chairman, you appear quite interested in the tungsten statistics. May I present a table here for the record giving some history on the United States?

Senator MALONE. This table shows the production, shipments from mines, imports for consumption, consumption, industry stocks at the

end of the year, producers, consumers and dealers, and a total. It will be submitted for the record. It covers the period from 1939 to July 1953.

(The document is as follows:)

Salient statistics of tungsten ores and concentrates in the United States, 1939–53, in pounds of contained tungsten

Year	Production	Shipments from mines	Imports for consumption	Consumption	Industry stocks at end of year		
					Producers	Consumers and dealers	Total
1939	3,429,047	4,080,024	1,485,157	(1)	283,863	2,667,738	2,951,541
1940	4,872,806	5,062,199	5,610,882	9,955,000	93,618	2,803,249	2,896,867
1941	6,420,303	6,249,945	11,522,190	16,699,000	263,626	2,404,876	2,668,502
1942	8,977,575	8,882,403	14,326,470	17,389,000	355,864	3,416,438	3,772,302
1943	11,472,985	11,368,295	19,445,017	19,313,000	458,586	2,459,246	2,917,832
1944	9,764,647	9,786,537	18,396,277	19,165,000	435,634	1,510,419	1,946,053
1945	5,388,639	5,266,818	4,773,861	14,146,000	557,042	3,784,429	4,341,471
1946	4,671,042	4,942,282	6,869,438	6,458,000	285,865	3,694,256	3,980,121
1947	3,026,470	2,944,622	6,018,005	7,812,000	368,316	3,343,392	3,711,708
1948	4,033,389	3,838,287	7,548,191	8,853,000	563,418	5,284,901	5,848,319
1949	2,896,084	2,631,506	6,274,102	4,958,000	827,045	4,229,444	5,056,489
1950	3,965,040	4,587,687	16,147,313	6,597,000	216,468	5,121,206	5,337,674
1951	5,913,750	5,972,551	6,376,513	11,410,000	234,282	4,037,502	4,271,784
1952	7,233,199	7,243,589	17,405,869	8,634,000	208,300	2,816,405	3,024,705
1953, 1st 6 months	4,163,773	4,089,223	14,215,543	4,484,200	287,102	2,594,518	2,881,620

[1] Not available.

Senator MALONE. This will be a part of your testimony. Do you intend at the end of your testimony to submit certain charts?

Mr. MELCHER. I understood the charts were available. I have a rather comprehensive review of each of these commodities that I would like to introduce.

Senator MALONE. To submit for the record?

Mr. MELCHER. Yes.

Senator MALONE. These charts contain the price per unit over the period 1915 to 1953, and the production, imports, and domestic production. The charts also show imports of the nations of the Western Hemisphere and all other foreign nations together with the consumption for each year, from 1940 to 1952; the source of imports and then a world chart showing the source of the foreign imports and also from the domestic production and the imports from the Western Hemisphere, for certain years.

Mr. MELCHER. May I suggest that these be added to the data I would like to submit?

Senator MALONE. Yes.

Mr. MELCHER. I have one further statement to make on tungsten. In 1952 Government participation through the Defense Minerals Exploration Administration contracts for exploration of domestic tungsten deposits exceeded $700,000. Many of the low-grade ores now being mined present metallurgical problems. The depletion of near-surface ore deposits will require a greater degree of mechanized underground mining with attendant high capital investment.

Senator MALONE. Do you preclude the discoveries of other deposits?

Mr. MELCHER. No, sir.

Senator MALONE. Are you aware that near Pioche, Nev., good accessible grades of tungsten and manganese have been discovered there since the Congress first passed the bill guaranteeing a profitable price.

Mr. MELCHER. That is right.

Senator MALONE. Of course, that is dependent upon the whim of Congress, but we were able to extend it 2 years. For 20 years I have listened to information coming out of the Department of Interior, unluckily not from experienced people, that we have discovered all of the readily available ores, taking it for granted that the millions of acres in each State have been minutely explored and that we know everything about the content of the earth's surface in those areas. Do you believe that?

Mr. MELCHER. It will be a long time before we ever reach that situation.

Senator MALONE. I agree with you. Therefore, any statement that we have exhausted the readily available supplies would have to assume that there would be no new discoveries, which is not reasonable, is it?

Mr. MELCHER. In another year or 2 years, or whenever we revise these charts, it will be a different story again.

Senator MALONE. That is correct, providing it is profitable to mine the ores in competition with the low-wage labor of the world.

Now, let me ask you this. About the time you were trying to discover some other type of ore in Idaho in World War II, did you accidentally discover one of the greatest tungsten deposits in the country?

Mr. MELCHER. That is right. We were drilling for antimony.

Senator MALONE. You were drilling for some other kind of ore entirely, antimony, and you dropped right into a large tungsten deposit.

Mr. MELCHER. Yes, sir.

Senator MALONE. With diamond drills and the advent of the new geophysical methods used in exploring, is it not logical to suppose that you will find more ore than you ever have found if mining is a profitable venture?

Mr. MELCHER. There is always that possibility.

Senator MALONE. Many of us can remember when there were thousands of prospectors in the hills, many of them with no college background or high-school education, and some of them without a grade-school education, who could tell you with a little pan, after a day or two of prospecting what percentage the ore would run per ton. Is that not true?

Mr. MELCHER. They would be very close.

Senator MALONE. Many of my acquaintances could do that. Where are they now? Are they developing any new mines? For 20 years it has been unprofitable for them to do that. These boys, even if they found tungsten, could not sell it until we passed a special bill in Congress to make it profitable for them to mine tungsten in competition with the low-cost labor of the world.

Mr. MELCHER. You are touching on a problem that is very acute with us in obtaining young men for the field.

Senator MALONE. There is no future in it unless we have a long-range policy, is there?

Mr. MELCHER. I still have faith in the mining industry.

Senator MALONE. I have faith in the mining industry, but I have very little faith in Government officials who can fix the price of metals and can manipulate the stockpile to break the market any time they want. In other words, a prospector, a miner, or an investor in mines is not dependent on his own judgment as it was in the past. He is dependent on some man in Washington who may not

know a pound of ore from a bale of hay. I am not talking about you. Each one of these men in this room knows the business, and if they let you do it, that would be one thing. This is the first time most of you fellows have ever been asked to testify before a committee.

Mr. MELCHER. That is true of some of us.

Senator MALONE. What I am trying to say is that we have a political reason for producing manganese in Burma or India. You did not mention India, but half of your manganese in our stockpile comes from India.

Mr. MELCHER. A large portion.

Senator MALONE. Do you think we are going to get any manganese from India when world war IV begins?

Mr. MELCHER. It is a long ways away.

Senator MALONE. I agree with you. Your testimony about manganese was very helpful. So if we could ever blow away the 20 years' assumption that the way to mine ores is to save them until the war starts it would be very helpful to the United States of America. Would you agree with that statement?

Mr. MELCHER. There are many of us that do not believe that is the way of doing it.

Senator MALONE. How long does it take after a prospector comes in looking for some engineer to go out and examine his little discovery, and the engineer decides that it will bear a certain amount of expense—it takes hundreds of those kinds to make one producer, and dozens of producers to make a good mine before you are in production from a prospect? Is it 6 months, a year, or 5 years?

Mr. MELCHER. On a large development I would say it takes 10 years.

Senator MALONE. Then you are getting ready for the war following the war you are trying to prepare for, if you do not start your production until the war starts.

Mr. MELCHER. That development can be accelerated, of course, in times of real emergency.

Senator MALONE. But it takes time to sink a shaft and to dig hard rock.

Mr. MELCHER. It takes time.

Senator MALONE. Suppose it took 5 years. You are not preparing for the current war. You are preparing for the war after that, are you not?

Mr. MELCHER. Assuming it lasts less than 5 years.

Senator MALONE. That has been the average. Maybe the next one will last longer and we might get into production if it lasts over 10 years. I am talking about a practical mining matter. If you do not have a going concern mining industry, you are not in very good shape.

Mr. MELCHER. Very definitely.

Senator MALONE. Would you like to submit your charts and material?

Mr. MELCHER. Yes, sir.

Senator MALONE. The charts, together with your prepared statement, will be submitted, and made a part of the record at this point.

(The documents are as follows:)

THE IRON ORE POSITION OF THE WESTERN HEMISPHERE

Deposits of high-grade iron ore in the Western Hemisphere hold adequate tonnages to assure supplies during the foreseeable future. Reserves in North America are adequate for a similar assurance if exception is made for premium

grade ores used in open-hearth steel furnaces. Deposits within the borders of the United States are of sufficient magnitude to support domestic requirements for the foreseeable future only if subgrade ore reserves are included and if no consideration is accorded with respect to transportation problems, costs of beneficiation, and the time element in providing beneficiation facilities.

POSITION OF THE UNITED STATES

Essentially, the problem of supplying iron ore for domestic consumption is one of balancing costs, conservation of reserves, and preservation of national security, in reverse order of importance.

The great magnitude of current requirements and prospects for continued expansion of these requirements, when fully appreciated, tend to make domestic reserves of easily obtainable ore seem quite small. On the other hand, reserves of iron-bearing material that may be classified as submarginal are of such proportions that no fear of eventual depletion need be entertained.

However, the influence of the iron and steel industry on the national economy, when considered from mining to retail sales of manufactured products, is such that unbalanced cost increases would affect national security. Similiarly, indiscriminate depletion of high-grade reserves has definite security aspects as well. Transportation problems would be created if it should become desirable or necessary to supply ore from one mining district to a consuming district ordinarily dependent on other sources. Excess rail capacity could not be expected to be available in such an eventuality; moreover, smelting practice might be exceedingly difficult to adjust to the use of different ores in some instances.

Furnaces east of the Mississippi River and north of Tennessee and Virginia constitute about 82 percent of domestic pig iron manufacturing capacity. These are dependent on ore from the Lake Superior district, primarily, but also include the principal consumers of imported ore and most of the furnaces expecting to depend on imported ore. Supply for furnaces outside this area is not likely to become critical, nor could the sources supplying ore to these furnaces contribute much to central and eastern districts in an emergency. Should imports be curtailed for any reason during the next 10 to 15 years the Lake Superior district would be called upon once again to supply emergency tonnages. The district could supply such tonnages now, but this flexibility becomes less each year.

No one can state with accuracy the ultimate tonnage of ore remaining in Minnesota, Michigan, and Wisconsin. If estimates are limited to direct-shipping grades and concentrating grades obtainable by proved processes, the tonnage is at least 1.9 billion tons. Undoubtedly the eventual quantity of usable iron ore to be extracted will greatly exceed this total as technological advances permit the treatment of lower-grade materials. Yet, consideration must be given to availability of the ore and concentrates.

In the 1.9-billion-ton reserve is a total of 498 million tons of open-pit direct-shipping ore. This is the most easily obtainable portion of reserves, and its strategic value derives from the fact that production can be greatly expanded in quick response to demand. This advantage has been exploited in three war emergencies, and the question arises as to the remaining expansibility.

One-half-billion tons plus seems a substantial reserve for emergency use. But it must be remembered that from this reserve 52 million tons were taken in 1951 and a similar tonnage will be taken in 1953. New reserves were reported to replace much of this depletion, but the extent of undeveloped properties now remaining do not indicate a probability of large unreported tonnages. The ultimate tonnage will be higher than 498 million. However, increasing difficulties in proving additional ore in this category do not permit estimates to double that figure. Moreover, the expansibility feature will be dissipated long before reserves are exhausted, and the addition of manpower and equipment will not be feasible beyond a certain point as selective mining becomes increasingly difficult.

Thus, the problem may be narrowed down to its most critical aspect: the strategic advantages of domestic high-grade open-pit ores and how best to conserve them. The problem was anticipated by a few in the prewar years. Later, it was apparent to many that some relief from the heavy drain on Lake Superior ores would be necessary if the United States iron and steel industry was to retain a reasonable domestic reserve to support emergency demand. It may seem surprising that the largest companies, holding the greatest quantity of domestic reserves, were first to make a concerted attempt to find nearby foreign sources. However, they were best equipped with personnel and finances, and perhaps recognized the problem first. At any rate, a great deal of money was expended in

exploration while a less intensive effort was made to develop the technology of ore dressing.

The pattern of future iron-ore supply began to emerge in 1948 and by the end of 1951 was clear in its major details. The outbreak of the Korean war had the effect of accelerating development of new foreign sources and, during its course and the mobilization effort, depletion of domestic open-pit reserves also was accelerated; no alternative was available.

It now appears that 30 to 40 percent of United States iron-ore supply will come from nondomestic sources by 1970. Canada will supply an important share from deposits that will offset to a substantial degree loss of strategic advantages due to the diminishing expansibility of Lake Superior open pits. Domestic mines may be expected to maintain output capacity not too far below its present level if technology is advanced at an acceptable rate. However, the economics of iron-ore concentration demand a relatively stable level of operations, and fluctuations must be absorbed largely by open pits.

A great deal of publicity has attended initial development of taconite which has given the erroneous impression to some that it would solve the iron-ore supply problem. Taconite is important, but insufficient cost data are available as yet upon which to base valid estimates as to its time position in future supply. Facilities now planned and under construction will provide some of the necessary information. However, expansion beyond these preliminary commercial operations will depend on many factors now unpredictable

Operating facilities with an annual capacity of 10–15 million tons of taconite concentrates will serve to illustrate the existence of an alternative to foreign supply, but it would not be an adequate alternative available for use in an emergency. Exploitation of the low-grade ores will require many more years to develop and it is more than doubtful if expansion of concentrate output can offset the decline of untreated ore production during the decades of 1960 and 1970.

POSITION OF CANADA

The Dominion of Canada has been a net importer of iron ore in its trade with the United States. Lake Superior ore going to Canadian furnaces has exceeded the tonnage of Algoma sinter exported to United States furnaces for a number of years. Wabana hematite from Newfoundland has gone principally to furnaces in Nova Scotia and the United Kingdom inasmuch as United States smelting practice can utilize only small quantities of high-phosphorus ore. In recent years, an exceptionally good grade of hematite has been shipped from Steep Rock mines in the Atikoken district of Ontario. However, the combined tonnages are still less than United States exports to Canada.

The importance of Canada in the future iron-ore supply pattern lies in large deposits now under development in Labrador and New Quebec. Other deposits are being developed and Steep Rock output will be increased, but the Quebec-Labrador deposits have a potential with practical limitations only in transportation. Proved reserves of direct-shipping grades total 418 million tons, and visual evidence supported by geologic interpretation indicates that this total can be doubled at least. The reserves of ore concentratable by conventional methods may be classified as unlimited for practical considerations.

Equally important with the quantities of ore in Canada is the availability of these supplies for emergency use. Steep Rock, Algoma (Michipicoten district), Marmora, and others in Ontario will supply substantial quantities over the Great Lakes transportation system. However, these do not include the expansibility feature so important in emergency demand situations.

The Quebec-Labrador deposits will be worked by open-pit methods and production can be expanded or curtailed as on the Mesabi range. The railroad is nearing completion (scheduled for July 1954) from the deposits to the Gulf of St. Lawrence. When completed, the railroad will be capable of moving 10 million tons per season; the magnitude of requirements expected during the decade 1955–65. If necessary, additional sidings and other facilities can be constructed in a reasonable period of time to increase the capacity of the railroad as desired. Eventually, full double tracking will be installed.

From Seven Islands on the Gulf of St. Lawrence some of the ore will move up the river and over existing canal and rail routes to furnaces in the central district. Perhaps larger tonnages will move out of the St. Lawrence and down the Atlantic coast to Philadelphia and Baltimore, thence by rail to furnaces in the central district as well as eastern Pennsylvania. Any tonnages moving by open-sea lanes cannot be considered secure in the event of submarine warfare. However, Canada has announced its intention to proceed with construction of the St. Lawrence seaway with or without United States participation. Cana-

dian iron-ore deposits are expected to be capable of supplying as much as 35 million tons per year by 1970.

POSITION OF VENEZUELA

Available information indicates that Venezuela and Canada should be ranked together as potential suppliers of iron ore to the United States. Ultimate reserves of each are large enough to make an accurate estimate of only academic importance. Two principal features differentiate these sources. Both will be open-pit operations, but only Venezuela has a climate for year-round production. Both have developed adequate transportation facilities, but Venezuelan ore must travel open-sea lanes. Another consideration should be noted: Supplies from Venezuela will encourage the migration of furnaces to coastal areas of the United States, while Canadian ore, with the St. Lawrence seaway, will tend to stabilize industry in place.

Bethlehem Steel's El Pao mine began shipments in 1951. The supply route covers 30 miles of rail from the deposit to San Felix on the south bank of the Orinoco River, thence down the Orinoco by river boat and barge to Puerto Hierro for transshipment to oceangoing ore carriers, thence to Baltimore. El Pao ore is high grade and reserves are on the order of 60 million tons.

Cerro Bolivar, under development by United States Steel Corp., is a much larger deposit of somewhat lower grade than El Pao; reserves are in excess of one-half-billion tons. Ore will move by rail to the new river port of Ordaz and down a dredged channel in the Orinoco in oceangoing vessels. Initial shipments are expected before 1955, and the annual output will be adjusted to requirements. Other deposits in the Orinoco River Basin eventually may prove to contain enormous additional reserves.

POSITION OF BRAZIL

Although Brazil has iron ore in quantities comparable to those of any nation in the world, internal transportation shows no indication of improvement that would permit greatly increased exports. Nevertheless, ore imported from Brazil is of special importance to the United States; it is a near-perfect material that performs special functions in making open-hearth steel. The price of this material is much higher than blast-furnace grades and has tended to retard import increases. However, imports reached 1 million tons in 1951 and were at the same level in 1952.

POSITION OF OTHER LATIN AMERICAN COUNTRIES

Mexico.—Reserves in Mexico have been estimated at 290 million tons. Exports are discouraged by the current administration in the hope that domestic smelting facilities will be expanded.

Cuba.—A potential supply of large proportions exists in Cuba where lateritic iron-ore deposits carrying chrome and nickel are easily obtainable. Extensive research is planned to develop means for eliminating these elements which prevent its use in current smelting practice. Cuba's position is important when considered on a long-range basis.

Chile.—This source has been an important supplier to the United States. Its reserves are declining and domestic consumers desire to retain most of the remaining ore. Imports from Chile will continue for some years, but at a substantially reduced level.

Peru.—Imports from Peru began this year and will total over 1 million tons annually during the next few years. Reserves are relatively small and the source appears unreliable for long-range consideration.

RECOMMENDATIONS

United States requirements for iron ore have outgrown domestic supply from existing sources. Adequate additional sources have been developed, or will soon be developed in the Western Hemisphere to assure supplies of ore requirements during the next 20 to 30 years. However, the outlook indicates that supplies from outside the United States will constitute 30 to 40 percent of the annual total by 1970.

It is recommended that every encouragement should be given to facilitate iron-ore imports on grounds that these supplies will conserve domestic reserves and that no alternative is available. At the same time, efforts to develop an

alternative through the technology of ore dressing should be accelerated so that the degree of dependence on outside sources can be minimized.

It is recommended that Government agencies be authorized and directed to intensify scientific research designed to develop means of beneficiating low-grade ores in a commercially feasible manner. In addition to the substantial work being done in industrial laboratories, many avenues of research remain unexplored and await efforts not restricted by the necessity for realizable results. An important example of results attributable to Government research may be drawn from magnetic taconite development: Pioneer research on the agglomeration of the concentrates was performed in the Mines Experiment Station, University of Minnesota where work was done by Federal and State technologists under the direction of Dr. E. W. Davis. A process was developed that is to be used in the large plant under construction at Beaver Bay, Minn.

A need exists for experimentation in connection with flotation, chemical, and pyrometallurgical methods of ore treatment. Processes have been developed on a laboratory scale that need testing on a pilot-plant scale. Effort should be made to modify smelting practice to utilize lower grade ores and fuels, and to permit economic operation in smaller units.

An effective 10-year program of Government research which would encompass investigation of mining difficulties, laboratory experiments, pilot-plant testing facilities, correlation of the available information on domestic reserves, and field exploration for new deposits as well as extensions of known deposits is estimated to be possible on a total appropriation of $30 million. It is difficult to conceive of a more rewarding investment in the conservation field, or one that would be likely to provide more tangible results. Delay in the initiation of an organized approach can only result in greater costs when the need becomes more urgent, and meanwhile, national security is jeopardized to the extent that iron-ore supplies become dependent upon open-sea lanes of transportation.

Estimates of iron-ore reserves of the United States by geographical regions—Direct shipping ore and concentrates by present methods of beneficiation [1]

[Millions of gross tons]

Region and State	(1) Measured		(2) Measured and indicated (includes col. 1)		Measured, indicated, and inferred (includes col. 2)	
Lake Superior region: Minnesota, Michigan, Wisconsin, total		1,124		1,720		2,605
Northeastern region: New York, New Jersey, Pennsylvania, total				300		380
Southeastern region:						
Alabama and Georgia			968		968	
Tennessee, Virginia, North Carolina, West Virginia, Kentucky			160		659	
Total				1,128		1,627
Central and Gulf region:						
Missouri			2		4	
Texas	17		27		60	
Total		17		29		64
Western region:						
Utah			100		350	
Wyoming			25		25	
California	28		33		54	
New Mexico			19		39	
Nevada			11		16	
Total		28		188		484
Total, United States		1,169		3,365		6,160

[1] Compiled by U. S. Geological Survey, and Bureau of Mines.

Estimated iron-ore resources of selected foreign countries

[In millions of gross tons]

	Direct shipping ore	Crude material for concentration		Direct shipping ore	Crude material for concentration
Labrador-Quebec [1]	400	(2)	Chile [7]	38	
Newfoundland [2]	2,500–3,500		Cuba [8]		3,000
Ontario [4]	75	136	Liberia [9]	20	100
Venezuela [5]	1,060		Algeria and Tunisia [10]	125	
Brazil [6]	1,500	3,500	Sweden [11]	2,300	150

[1] Steel magazine, 1950.
[2] Large.
[3] Hayes, 1931; DeMille, 1949.
[4] Engineering and Mining Journal, 1948, pp. 84–85; Moore, 1948.
[5] Lippert, 1950, pp. 184, 190.
[6] U. S. Bureau of Mines, 1941.
[7] Engineering and Mining Journal, 1948, p. 142; Lippert, 1950, p. 184.
[8] U. S. Department of State, 1947, p. 15; Eckel, 1914, p. 388.
[9] U. S. Geological Survey, 1945; unpublished data.
[10] U. S. Department of State, 1947, pp. 18–19; Eckel, 1914, p. 336.
[11] Ross, 1950; U. S. Department of State, 1947, p. 8.

United States iron-ore production, by districts, 1933–52, in thousand of gross tons

	Lake Superior district	Southeastern States	Northeastern States	Western States	Total
1933	14,611	2,160	396	386	17,553
1934	21,031	2,348	909	300	24,588
1935	25,360	3,256	1,352	516	30,484
1936	41,781	4,215	2,070	723	48,789
1937	61,658	6,351	3,145	940	72,094
1938	21,308	4,326	2,307	506	28,447
1939	41,680	6,022	3,113	917	51,732
1940	61,471	7,446	3,560	1,219	73,696
1941	78,858	8,146	3,962	1,443	92,409
1942	91,005	9,159	3,120	1,599	104,883
1943	85,789	8,479	3,467	2,860	100,595
1944	79,111	7,122	3,849	3,443	93,525
1945	74,821	6,330	3,620	3,088	87,859
1946	59,042	6,247	2,596	2,451	70,336
1947	76,532	7,527	3,987	4,503	92,549
1948	82,630	8,365	4,423	5,105	100,523
1949	68,494	7,602	3,864	4,442	84,402
1950	79,627	7,507	4,475	5,861	97,470
1951	93,947	8,587	5,181	8,181	[1] 115,936
1952	77,095	7,624	4,426	8,030	[1] 97,314

[1] Includes a small tonnage of Puerto Rican ore.

Iron are imported for consumption in the United States, 1943–52 [1]

[In gross tons]

Country	1943–47 average	1948	1949	1950	1951	1952
Algeria	112,486	405,224	415,501	494,342	446,273	66,008
Argentina	4		20			
Belgium-Luxembourg	244	2				
Brazil	17,109	295,926	351,134	701,329	1,037,828	1,010,919
British West Africa	4,594	18,528	59,548	192,669	255,817	217,760
Canada	779,866	985,846	1,615,803	1,852,508	1,961,990	1,822,038
Chile	594,508	2,631,997	2,627,007	2,606,557	2,767,207	1,861,575
Columbia	2					
Costa Rica						449
Cuba	62,312	34,500	11,589	29,000	4,223	87,536
Denmark	4,892					
Dominican Republic						18,408
Egypt			7,500			
France	934	9,041		500		
French Morocco	5,455	8,690				
Greece	400					
Iran	300	3,000	1,500	3,000	1,500	2,972
Italy	103	9,451				
Liberia		4	30	(2)	110,123	572,485
Mexico	34,581	163,149	169,823	190,958	169,563	114,309
Netherlands			7,114			
Newfoundland-Labrador	3,100					
Norway	5,649	108,616				
Oceania, French	(2)					
Peru	3					
Phillipines		4,160	5,250	3,600		
Spain	1	6,449	9,200		74,306	4,600
Spanish Africa		8,500		39,680	8,750	
Sweden	303,957	1,358,962	2,027,155	2,047,250	2,522,011	2,111,100
Tunisia	9,359	56,358	82,815	119,093	134,775	19,200
Union of South Africa	1,787				9,450	4,800
United Kingdom	444	351	302	751	446	690
Venezuela					635,416	1,845,776
Total	1,942,090	6,108,754	7,391,291	8,281,237	10,139,678	9,760,625

[1] In addition 15,735 tons of pyrites cinder were imported in 1950; 8,675 tons in 1951; 11,149 tons in 1952; all from Canada.
[2] Less than 1 ton.

Chromite Position of the Western Hemisphere

United States production of chromite in 1952, most of which was produced at high incentive prices, constituted less than 1 percent of the total world production; Western Hemisphere production amounted to less than 3 percent of the world total. In sharp contrast with this production is consumption; the United States consumed one-third of the total world production of chromite, with the Western Hemisphere accounting for a somewhat higher percentage.

What is needed to make more effective use of Western Hemisphere reserves is (1) considerable mining and metallurgical research designed to lower the production cost of chromite from the substantial reserves of low-grade ores, and (2) a program designed to demonstrate the feasibility of using lower grade concentrates through revisions in general metallurgical methods. These, plus additional research on the utilization of the chromium contained in the lateritic iron ores of Cuba (about 17 percent of estimated world resources of 300 million tons of Cr_2O_3) would make the chromite position of the Western Hemisphere considerably more comfortable than it is currently.

STRATEGIC CONSIDERATIONS

Chromite is high on the list of strategic and critical minerals with large tonnages needed for stockpiling. Wartime needs for chromite far exceed those of normal periods of high industrial activity. Moreover, the important sources of better grades of chromite involve serious transportation risks during wartime. Consuming plants in the United States are widely scattered and do not present an unusual plant-protection problem.

USES

Chromium finds its application in three fairly independent fields as indicated by the general grade designations of the ore, metallurgical, refractory, and

chemical. Physical and chemical characteristics as well as price determine the grade of the ore. Distribution of ore consumption, percentagewise, reveals that in 1952, 57 percent was consumed in the manufacture of ferrochromium and other chromium-bearing metals; 33 percent was consumed in the manufacture of refractory materials and 10 percent in chemical processes.

The largest and best known use of chromium is in the manufacture of stainless steels. The element, however, is widely used also in low-alloy, high-strength steels and in numerous new alloys for high-temperature service, such as those to be used in jet engines and gas turbines. A remarkable resistance to corrosion and fatigue at high temperatures places chromium in heavy demand for these uses.

Refractory chromite is chemically neutral and, therefore, is made into bricks and used to separate acid roofs from basic bottoms in open-hearth furnaces. Chrome cements are used for special refractory purposes. The chemical products made from chromite are used principally in the manufacture of pigments, the tanning of leather, and surface treatment of metals. Additional uses are in textile, chemical, and dye manufacture, and in making of chromium metal.

SUBSTITUTES

There are no known substitutes for most chemical and metallurgical uses of chromite. For refractory purposes, however, magnesite can be substituted for chromite for many purposes at additional cost to the consumer. Probably a saving of as much as 25 percent of refractory chromite could be made by this substitution.

PRICES

Prices for imported chromite have been relatively steady during 1952 and early 1953. The three different grades of ore command prices as in the following table wherein quotations are on the basis of long dry ton, f.o.b. cars, Atlantic ports:

Metallurgical ore: 48 percent Cr_2O_3, 3:1 chrome iron ratio, Rhodesian $44–$46, Turkish $54–$55.

Chemical ore: 44 percent Cr_2O_3, no ratio, Transvaal, $27–$28.

Refractory ore: Prices are not quoted but probably range from $25 to $35.

Domestic chromite is being purchased by the Government at a base price of $115 for lump ore containing 48 percent Cr_2O_3 with a 3:1 chrome-iron ratio.

TARIFFS

There is no duty on imports of chrome ore, however, chrome alloys and chromium metal are dutiable as in the following schedule:

Ferrochrome over 3 percent carbon: 5/8 cents per pound of contained chromium.

Ferrochrome less than 3 percent carbon, other chrome alloys, and chrome metal: 12½ percent ad valorem.

RESERVES

If the Western Hemisphere were able to satisfy its chromium needs solely from its own commercial reserves of chromite (including commercially acceptable ore being mined at subsidy prices) the reserves would be depleted in 1 year. United States reserves would last less than 2 months. If consideration were given to all reserves of chrome ore in the United States and Alaska, including deposits that are not currently commercial for economic or technologic reasons, the entire supply would be exhausted in less than 7 years.

In 1952, consumption of chromite in the Western Hemisphere totaled an estimated 1,334,000 short tons, with the United States accounting for 1,185,460 short tons of this total. If reserves are computed on the basis of what is economically minable at current commercial prices without considering the unusually high prices paid by the Government, United States reserves are virtually nil; thus the entire consumption requirement must be filled by foreign ore. The same would apply for continental North America. Considering the entire Western Hemisphere, Cuba's reserves amount to a total of about 550,000 tons of ore, 500,000 tons refractory and 50,000 metallurgical. Brazil has about 50,000 tons, but cannot be considered as a source for United States consumption as its production in the main is consumed internally. Guatemala's high-grade ore is spotty and reserves in terms of United States consumption needs can be discounted completely.

United States

Current chromite reserves are located in California, Montana, Oregon, and Alaska. Some of the California and Oregon ores are acceptable in current commercial practice, but cannot be mined profitably at current commercial prices. In this category belong the California and Oregon ores being purchased by the Government at more than twice the price of the costliest foreign ores (Turkish), as well as the Alaskan deposits being developed at Red Mountain on the Kenai Peninsula with the impetus of a Government loan and purchase contract.

Montana's extensive deposits in the Stillwater complex are low grade and not acceptable in general commercial practice. The same statement applies to the rather large deposits of chrome-bearing beach sands in Oregon (about 250,000 tons Cr_2O_3). Although the Mouat deposit in Montana, which comprises a major portion of the Montana reserves, is currently being mined by private industry with the aid of a loan and purchase contract from the United States Government, the resulting concentrates are not usable in general commercial practice, and cannot be sold profitably to industry at current market prices. While it is generally recogniezd that ores containing low chrome and high iron can be used by industry, it is also recognized that as long as high-grade foreign ores are available at comparatively low prices, economics and custom will prevail. Should low-grade, high-iron-content ores become acceptable, several hundreds of thousand of tons of such ores scattered through California and Oregon may also be looked to as reserves.

Experimental work performed by the Bureau of Mines in cooperation with industry has proved that domestic reserves of low-grade concentrates can be used successfully for some metallurgical and refractory purposes.

ULTIMATE RESERVES

Canada

About 10 million tons of low-grade, high iron chrome ore containing about 2 million tons of Cr_2O_3 are available in the Bird River area of Manitoba. Such ore could be used without further advances in technologic research should economics and urgency so dictate.

Cuba

Although capable of a large production of refractory ore—in 1943, Cuba produced 348,560 long tons of chromite, 20 percent of the world total—the competition of more easily mined and better-grade refractory ore from the Philippines has decreased the Cuban output considerably. The major production has been from the Provinces of Oriente, Camaguey, and Matanzas, although chromite is found in much of the northern half of the island. Total Cuban reserves of chrome ore are estimated at 2,750,000 tons containing 800,000 tons of Cr_2O_3. About 50 million tons of Cr_2O_3 are contained in the chromiferous lateritic iron ores, but these reserves cannot be utilized without further advances in mining and metallurgy. The United States Bureau of Mines is currently working on this problem.

Brazil

Brazilian chromites are chiefly low grade (30 to 42 percent Cr_2O_3); reserves are estimated at 40,000 tons of Cr_2O_3, mostly from the States of Bahia and Goiaz. Additional undetermined reserves are contained in Minas Gerais and Amapa. Brazil's peak production during World War II was less than 8,000 tons (1943), and of late has been between 2,000 and 3,000 tons. Most current production is consumed internally.

United States

Ultimate chromite reserves of the United States, chiefly low-grade, high iron ores, amount to about 3½ million tons of contained Cr_2O_3, or about 7 years' supply at the 1952 consumption level, if all the Cr_2O_3 could be utilized.

OVERSEAS SOURCES

Africa

Both Southern Rhodesia and adjacent Union of South Africa are important sources of chromite for the United States, with reserves which are the largest known anywhere at the present time, amounting to hundreds of millions of tons.

The mining industry in the Union is owned locally, but the bulk of Southern Rhodesian production is by companies affiliated with United States consumers. Production in both areas is for export, with the exception of small local sales. In 1952, the output of both countries combined was 35 percent of the world total

(U. S. S. R. excluded), which compares with 3 percent for the Western Hemisphere, 25 percent for Turkey, and 21 percent for Philippines (of which about 92 percent was refractory ore).

The importance of the African supply of chromite to the United States is evident in the table below, showing this country's 1952 imports of the ore by grades, and also the percentage of total chrome imports represented.

	Imports from Union of South Africa		Imports from Southern Rhodesia		For both countries combined	
	Quantity	Percent of total imports	Quantity	Percent of total imports	Quantity	Percent of total imports
Metallurgical	88,106	9.6	172,515	18.8	260,621	28.4
Refractory	22,609	3.8	11,057	1.8	33,666	5.6
Chemical	189,065	100.0	0	0	189,065	100.0
All grades	299,780	17.6	183,572	10.8	483,352	28.4

That imports from Africa in 1952 were not substantially larger was due primarily to the failure of the railroads (Government owned) to handle all offerings of export ore; thus Southern Rhodesia ended the year with over a half million tons of chrome in stockpiles above ground.

The chrome exports of both countries are through Indian Ocean ports situated in Mozambique, a Portuguese colony. The port for Union ore is Lourenco Marques, and that for Rhodesian ore, Beira. Maximum rail haul for chrome to these ports is around 400 miles and 500 miles, respectively. Capacity at Beira, which handles other exports, became inadequate during the current boom but recently has been enlarged. To relieve the port further, a new railroad is now under construction from Southern Rhodesia to Lourenco Marques. There is no direct rail route from the main mineral producing parts of the Union of Southern Rhodesia westerly to the Atlantic Ocean.

Limited chrome production also exists on the Atlantic side of Africa. The source is Sierra Leone, a British colony which exports via Freetown, situated at approximately latitude 12° north.

Yugoslavia

Since 1949 the production of chromite has been increasing, due to the fact that new mines were put into production and new mining pits were opened in the Radusa mining district. Deposits of chrome ore estimated to amount to about 500,000 tons were recently discovered in southwest Serbia. Yugoslavia's reserves, including the newly found deposits, have been estimated at 2 million tons.

Greece

Deposits of chromite are widely scattered through eastern and northeastern Greece. Reserves for metallurgical and refractory grade chromite are estimated at 360,000 and 640,000 short tons, respectively. Production and exports have been small.

Turkey

In 1951, Turkey's output of 663,833 short tons of chromite was 22 percent of the world's total. In 1952 the production increased to an estimated 700,000 tons. Although the latter figure represents perhaps the maximum output to be expected from this country, it can be maintained for the next decade. Demand for chromite coupled with good prices as well as the excellence of some of the deposits have been the principal contributing factors to the rapid increase in the annual production during the last 5 years. In 1952, Turkey supplied about 27 percent of total chrome imports of the United States.

Most of the Turkish production is exported to the United States. Gravel and macadam roads connect the different mine groups to railheads or directly to ports on the Mediterranean, the Sea of Marmara, and the Black Sea. Rail plus road distances vary from 50 to 350 miles.

It is difficult to estimate reserves of chrome deposits because of the mode of occurrence. This is particularly true in Turkey where many private producers do not spend funds for exploration work. The latest estimate for chromite reserves in Turkey is 6,400,000 short tons, which is considered conservative. There is a large area where the geology is favorable for discovery of additional chromite deposits.

Pakistan

Since 1915 there has ben a steady production of chromite in Pakistan at annual rates which have varied from 15,000 to a maximum of 40,000 long tons (1942). The ore is of high quality metallurgical grade exported mainly to the United Kingdom. The output in terms of world total is not important.

Afghanistan

There are a number of chromite bodies in the Logar Valley, Afghanistan. Total indicated reserves are 180,000 tons of which nearly 30,000 tons meet or exceed the specifications of metallurgical chromite. Lack of transportation facilities within Afghanistan and the long, high-cost hauls to foreign markets are the problems confronting chromite mining enterprises. With good management, however, it may be economic to export the high-grade ore which commands a premium price in the world market.

Iran

Chromite deposits are known in at least three localities in northeast and southeast Iran. The deposits are generally podlike, similar to those of Afghanistan and Pakistan. Two of the deposits in Isfandaqeh near Kerman seem, according to available anaylses, to be of good grade. Some 7,000 tons of hand cobbed chromite have been prepared for export at this locality but have not been shipped as yet. Nearest port is Bandar Abbas some 300 miles away, and loading would have to be with lighters. It is believed that if markets exist, Iran may be able to export about 20,000 tons of ore per year.

Philippine Islands

Known reserves of chromite in the Philippines are on the order of 10.8 million tons, of which 10.1 million tons are refractory grade. The geology of the islands, however, indicates substantial quantities of undeveloped metallurgical ore. Chromite production has been expanding rapidly since 1950, with virtually all of the ore being exported to the United States. During 1952, the Philippines supplied the United States with 84 percent of its imports of refractory chromite.

New Caledonia

New Caledonia is the seventh largest producer of chromite in the world, and has accounted for about 4 percent of world output since World War II. Reserves are unknown, but it is reported that large tonnages of ore were uncovered during World War II.

Chromite imported for consumption in the United States, 1952, by countries, and by grades, in short tons

	Chemical grade		Metallurgical grade		Refractory grade		Total	
	Gross weight	Cr_2O_3 content	Gross weight	Cr_2O_3 content	Gross weight	Cr_2O_3 content	Gross weight	Cr_2O_3 content
Afghanistan			1,006	464			1,006	464
Cuba			40,421	15,939	56,333	20,515	96,754	36,454
Greece			246	118			246	118
Guatemala			1,458	846			1,458	846
India			6,581	2,931			6,581	2,931
New Caledonia [1]			58,776	29,778			58,776	29,778
Pakistan			3,372	1,577			3,372	1,577
Philippines			41,175	19,490	502,527	170,662	543,702	190,152
Sierra Leone [2]			26,846	10,769			26,846	10,769
Southern Rhodesia			172,515	82,514	11,057	4,784	183,572	87,298
Turkey			453,000	208,153	3,343	1,313	456,343	209,466
Union of South Africa	189,065	83,732	88,106	40,174	22,609	9,355	299,780	133,261
Yugoslavia			21,661	9,511			21,661	9,511
Total	189,065	83,732	915,163	422,264	595,869	206,629	1,700,097	712,625

[1] Classified as French Pacific Islands.
[2] Classified as British West Africa.

Source: U. S. Department of Commerce.

Production and consumption of chromite in 1952 and estimated reserves in the Western Hemisphere

[Short tons]

	1952 production ore and concentrates	1952 consumption		Reserves			
		Ore and concentrates	Cr_2O_3	Currently acceptable to industry (commercial)		Ultimate reserves (non-commercial)	
				Ore and concentrates	Cr_2O_3	Ore	Cr_2O_3
United States:							
Alaska				25,000	11,000	450,000	90,000
California	14,713			100,000	45,000	250,000	50,000
Montana						15,120,000	3,000,000
Oregon	6,591			30,000	15,500	4,000,000	300,000
Washington						150,000	27,000
Wyoming						400,000	43,000
Total	21,304	1,185,460	[1] 500,000	155,000	72,000	20,400,000	3,500,000
Canada		145,907	[1] 60,000			10,000,000	2,200,000
Guatemala	[1] 70						
Cuba:							
Camaguey (refractory)	68,131			250,000	87,500	1,600,000	450,000
Oriente (refractory), metallurgical				250,000	87,500	500,000	150,000
				50,000	22,000	100,000	25,000
Laterites						3,000,000,000	50,000,000
Total	68,131			550,000	200,000	3,002,200,000	50,700,000
Brazil: Bahia, Goiaz, Amapa, Minas Gerais	2,500	[1] 2,500	[1] 1,000	50,000	20,000	100,000	20,000
Total, Western Hemisphere	92,000	1,333,800	560,000	755,000	290,000	3,032,700,000	56,300,000

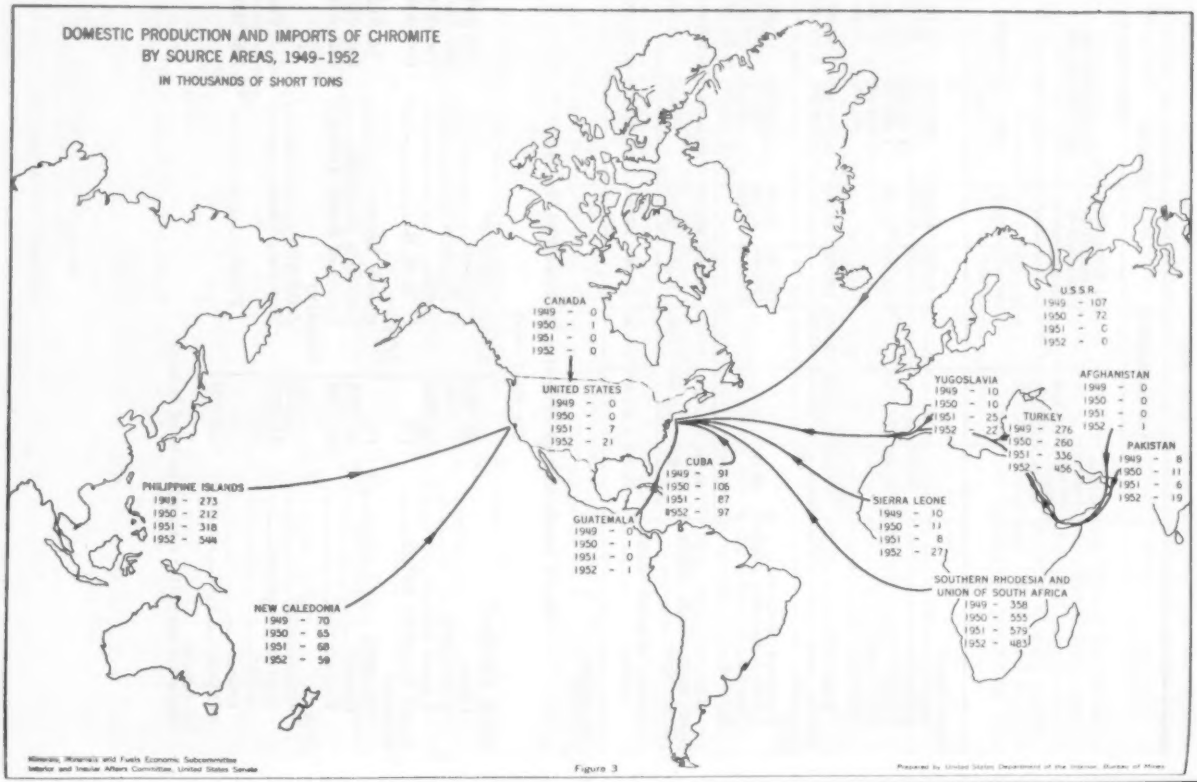
[1] Estimated.

World production of chromite, by countries, in 1952

[In short tons]

North America:	
Cuba	68,132
Guatemala	[1] 66
United States	21,304
South America: Brazil	([2])
Europe:	
Bulgaria	([2])
Greece	31,838
Yugoslavia	118,719
Asia:	
Afghanistan	1,102
Cyprus (exports)	13,318
India	([2])
Iran	([2])
Japan	[1] 52,000
Asia—Continued	
Pakistan	19,340
Philippines	599,121
Turkey	[1] 700,000
U. S. S. R	[1] 650,000
Africa:	
Sierra Leone	26,312
Southern Rhodesia	355,678
Union of South Africa	639,366
Oceania:	
Australia	([2])
New Caledonia	118,675
Total	[1] 3,500,000

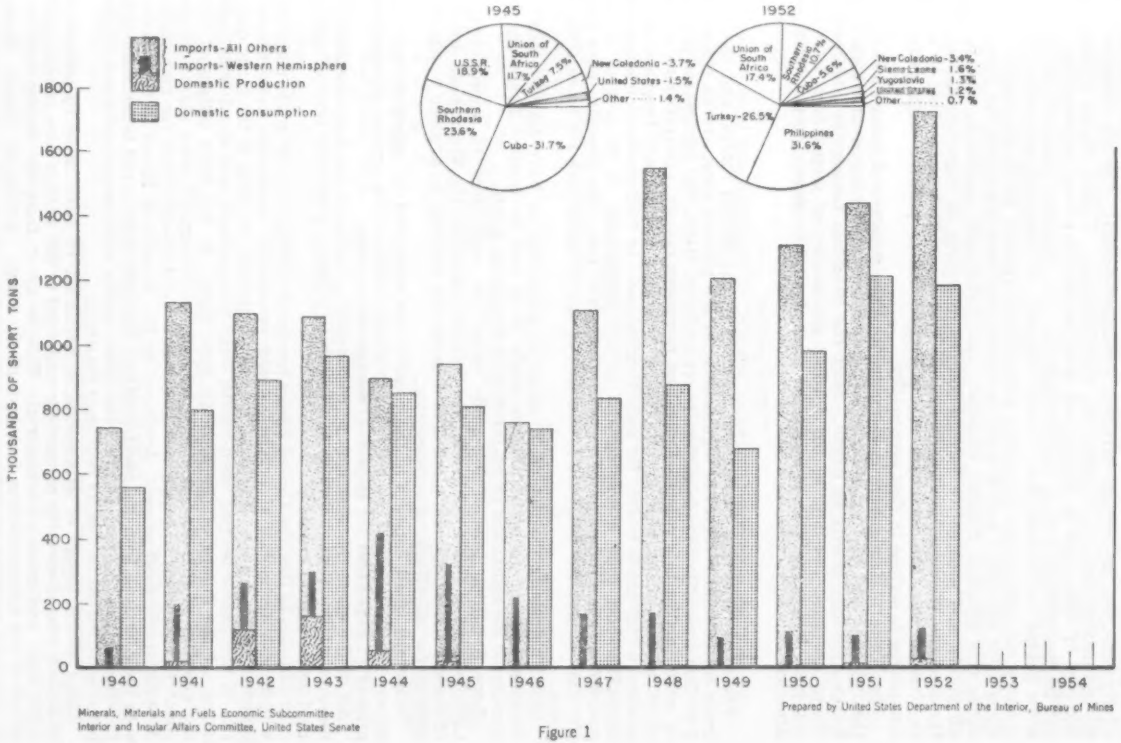
[1] Estimate.
[2] Data not available; estimate included in total.



SUPPLIES AND CONSUMPTION OF CHROMITE

1945 1952

SUPPLIES AND CONSUMPTION OF CHROMITE



Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Prepared by United States Department of the Interior, Bureau of Mines

Figure 1

THE MANGANESE POSITION OF THE WESTERN HEMISPHERE, OCTOBER 19, 1953

Manganese is necessary for the production of steel, and it is this use which accounts for the volume of manganese-ore consumption. Manganese in the form of a particular grade of manganese dioxide is essential for the manufacture of dry cells, but the tonnage involved is relatively small. Certain chemical uses for manganese ore are in much the same position. United States commercial reserves of these ores in comparison with respective annual consumption rates can be measured at best as approximately a 2- or 2½-year supply if production were geared to consumption. Large deposits of low-grade materials in this country can conceivably become a submarginal reserve under emergency conditions after successful beneficiation methods have been developed for them. Because this presents difficult economic and technologic problems, and because all known and prospective foreign sources of supply of importance, including those of the Western Hemisphere, entail long sea routes, vulnerable to attack in time of war, the weakness of the United States position with respect to manganese is serious in that eventuality.

The Western Hemisphere is estimated to have reserevs of manganese ore in the neighborhood of 70 million tons, approximately 90 percent of which is in South America—mostly in Brazil. Half the Brazilian tonnage is undeveloped. There are good possibilities for further discoveries of importance in South America, but very little prospect for such favorable developments in North America.

UNITED STATES

The most important commercial reserves in the United States, and the only truly commercial reserves of significance, at the present time, are an estimated 5 million tons of low-grade carbonate ore at Butte, Mont., the manganese content of which makes this reserve equivalent to approximately 1,500,000 tons of ore of 58 percent manganese grade. These Montana deposits are beneficiated to produce a high-grade nodule for metallurgical use. In 1952 production amounted to 90,772 short tons, averaging 57.5 percent manganese, or 90 percent of the entire domestic production of metallurgical-grade ore. The deposits have been the chief source for domestic production of metallurgical ore for more than 10 years.

The Philipsburg district of Montana is estimated to have 800,000 tons of carbonate ore of somewhat higher grade than that at Butte. They may be considered the equivalent of 375,000 tons of 48-percent grade.

Some 5 million tons of low-grade oxide ore, equivalent to approximately 1,100,000 tons of 48-percent grade, has been estimated for the Three Kids district of Nevada. A commercial plant is now using this material to produce manganese nodules for metallurgical consumption.

Numerous small deposits in the country are estimated to aggregate approximately 1 million tons of reserves that might be mined at the present Government price of $2.30 per unit for 48-percent-manganese content.

All of the above deposits may be considered to make up the total commercial reserves of the United States, equivalent to roughly 4 million tons of ore of good metallurgical grade.

In addition to this, the United States has large tonnages of low-grade materials which with technological progress could conceivably make the country self-sufficient in the future. Perhaps the most important of these is the large quantity of manganese-bearing open-hearth slags accumulated, and steadily accumulating, at the dumps of the Nation's steel mills. It has been estimated that the quantity of this slag produced annually at integrated steel plants in this country is sufficient to supply nearly one-half the domestic needs for manganese. A pyrometallurgical process, developed by the Bureau of Mines in cooperation with the American Iron and Steel Institute, has been determined to be technically feasible for the recovery of this manganese, and a semicommercial plant is now being constructed to test its economic feasibility.

The Cuyuna Range of Minnesota is estimated to have from 10 million to 25 million tons of metallic manganese contained in 500 million tons of manganiferous slate and associated material. This is apart from the manganese contained in the manganiferous iron ores of the range. Aroostook County, Maine, is estimated to have 28 million tons of metallic manganese in manganiferous ferruginous slates averaging about 9 percent manganese. Of this quantity, 22,800,000 tons of the element is contained in 256 million tons of rock at 1 deposit. At Artillery Peak, Ariz., are an estimated 7,500,000 tons of metallic man-

ganese contained in 195 million tons of rock. All of these deposits present difficult problems for the recovery of their manganese content. The Bureau of Mines is working to develop satisfactory methods of recovery, and has met with technical encouragement.

Outcropping for 120 miles along the Missouri River and its tributaries in South Dakota are manganese-bearing concretionary shales estimated to contain 45 million tons of metallic manganese in 2,500 million tons of rock, an average grade of 1½ percent. Although this is a tremendous tonnage, it presents unsolved mining and metallurgical problems which must await successful development of the higher grade deposits.

Since consumption of manganese in terms of ore in the United States has averaged 1,800,000 short tons per year for the past 5 years, it is apparent that the Nation will be virtually dependent upon foreign sources until its submarginal reserves are made available on a production basis.

CANADA

Canada has no important deposits of manganese ore. Apparent consumption of manganese ore in Canada has averaged 180,000 short tons per year for the past 5 years, and may be expected to increase. The country is now completely dependent upon foreign sources of supply for its manganese ore and will probably continue in that position, although there is some remote possibility for future discovery.

Production of manganese ore in 1952 and estimated reserves in the Western Hemisphere, in short tons

	Production of manganese ore, concentrate or nodule in 1952	Equipped or being equipped for production		Unequipped	
		Ore	Manganese content	Ore	Manganese content
North America:					
United States:					
Butte, Mont.	90,772	5,000,000	850,000		
Philipsburg, Mont.		800,000	180,000		
Three Kids, Nev.		5,000,000	500,000		
Miscellaneous small deposits.	10,227	[1] 1,000,000	[1] 350,000		
Chamberlain, S. Dak.				2,500,000,000	45,000,000
Cuyuna Range, Minn.				500,000,000	10,000,000–25,000,000
Aroostook County, Maine.				314,000,000	28,000,000
Artillery Peak, Ariz.				195,000,000	7,500,000
Open-hearth slags.				[2]	[2]
Total, United States.	100,999	11,800,000	1,880,000	3,509,000,000	90,500,000–105,500,000
Costa Rica.	91			5,000	2,000
Cuba.	277,424	[1] 1,000,000	[1] 400,000		
Mexico.	112,435	[1] 1,650,000	[1] 577,500		
Panama.				50,000	20,000
Total North America.	490,949	14,450,000	2,857,500	3,509,055,000	90,522,000–105,522,000
South America:					
Brazil:					
Minas Gerais.	[3] 176,368	4,000,000	1,760,000		
Bahia.	[2]	1,000,000	440,000		
Amapa.		25,000,000	12,500,000		
Urucum.				30,000,000	13,650,000
Total Brazil.	176,368	30,000,000	14,700,000	30,000,000	13,650,000
Chile.	41,887	1,200,000	420,000		
Peru.	597	[4]	[4]		
Total South America.	218,852	31,200,000	15,120,000	30,000,000	13,650,000
Total Western Hemisphere.	709,801	45,650,000	17,977,500	3,539,055,000	104,172,000–119,172,000

[1] Partly equipped, partly unequipped.
[2] Unmeasured.
[3] Most Brazilian production was from Minas Gerais, but some from Bahia.
[4] Unmeasured and not significant.

CUBA

At present most of Cuba's production of manganese ore comes from one mine, the Charco Redondo Mine in Oriente Province. Because of the uncertainty as to its reserves, and the fact that the rest of the country's reserves are distributed among relatively small deposits, figures varying from 400,000 to 1,800,000 tons have been estimated for Cuba's reserves. Taking everything into consideration, it is believed that 1 million tons is probably the most reasonable figure to use for commercial reserves.

MEXICO

Commercial reserves of manganese ore in Mexico are estimated at 1,650,000 short tons scattered over the country in small deposits. Shortage of railroad cars, poor roads, and other transportation difficulties hinder production. Mexico's annual consumption of manganese ore is in the nature of 13,000 to 17,000 short tons.

BRAZIL

Total reserves of manganese ore in Brazil are estimated at 60 million tons. Of these, 30 million tons having an average grade of 45½ percent are at Urucum, near the Bolivian border in Mato Grosso, some 2,000 miles from the coast. Although negotiations leading to their development have been under way for some time, exploitation of these deposits in the near future does not seem promising. The Bethlehem Steel Co., is now developing a deposit in the Territory of Amapa which contains 25 million tons of 50-percent ore. Most of Brazil's present production comes from Minas Gerais, where reserves are estimated at 4 million tons, but operations suffer from limitations of transportation. Relatively minor deposits are being mined in the State of Bahia.

Consumption of manganese ore in Brazil has been steadily increasing and is now estimated at approximately 41,000 short tons.

CHILE

Chilean reserves of good manganese ore are estimated to be 1,200,000 tons. Chilean consumption is expected to increase with the completion of a new ferromanganese plant so that all Chilean production will probably be consumed locally by 1956.

OTHER SOUTH AMERICAN AND CARIBBEAN COUNTRIES

Other South American and Caribbean countries have known manganese occurrences or have reported manganese discoveries, and the possibilities for discoveries of important commercial reserves in some of the countries are believed to be very good, particularly Venezuela.

SOURCES OF SUPPLY FOR UNITED STATES

In 1952, the United States obtained 4 percent of its supply of newly acquired manganese ore from domestic production, 37 percent from India, 30 percent from Africa, and 21 percent from the Western Hemisphere excluding the United States. Of the Western Hemisphere countries, Cuba supplied 9 percent of the United States' total newly acquired ore, Brazil 6 percent, Mexico 5 percent, Chile 1 percent, Peru less than 1 percent, and Costa Rica a small shipment of 91 short tons. Imports of ferromanganese accounted for only 4 percent of the United States' total acquisition of elemental manganese in 1952. Of this quantity, 48 percent came from Norway, 45 percent from Canada, 6 percent from France, and the remaining 1 percent from Yugoslavia and Western Germany.

Imports of manganese ore from Brazil may be expected to increase steadily until they will be on a level with those from India and Africa, and may conceivably replace India as the United States' principal supplier.

The largest reserves of manganese ore in the world are in Soviet Russia which cut off imports to the United States in 1950, and has only recently given indications of possible resumption. Russian ore, which is of high quality, formerly supplied as much as one-third of the United States imports. When the flow of this ore stopped, United States stocks fell to an extremely low level before other sources of supply, chiefly India and Africa, were able to fill the gap.

Engineering estimates of Indian manganese reserves are not available. However, reserves may well be about 100 million tons.

Ore reserves of Africa are also large, and are distributed among 10 different political divisions, certain of which are the United States' present and potential principal source of supply for battery and chemical grade ore.

TARIFFS

Tariffs on manganese ore in effect at present are as follows:

Manganese ore: one-fourth cent per pound contained manganese (except for ores from Cuba and the Philippines which are duty free, and except for ore from Soviet Russia and its associated countries for which a 1 cent per pound duty is applicable).

Manganese ore (sintered): 15 percent ad valorem.

Ferromanganese, 4 percent or more carbon: eleven-sixteenths cent per pound contained manganese.

Ferromanganese, 1 to 4 percent carbon: fifteen-sixteenths cent per pound contained manganese.

Ferromanganese, less than 1 percent: fifteen-sixteenths cent per pound plus 10 percent ad valorem.

Foreign governments also impose export duties on manganese ore in variable amounts, apparently chiefly for purposes of revenue rather than to restrict export.

Manganese ore imported into the United States in 1952, in short tons

Country	Gross weight	Manganese content	Country	Gross weight	Manganese content
Angola	64,559	31,501	Indonesia	13,126	5,959
Belgian Congo	54,144	27,000	Mexico	135,718	57,214
Brazil	169,372	75,052	New Zealand	545	265
Chile	28,311	12,596	Peru	3,687	1,736
Costa Rica	91	38	Philippines	10,587	4,677
Cuba	259,230	113,051	Portuguese Asia	55,815	23,902
French Morocco	85,316	42,608	Turkey	41,149	18,545
French Pacific Islands	22,459	10,303	Union of South Africa	319,719	140,552
Gold Coast	368,068	177,376			
Greece	8,372	3,175	Total	2,668,557	1,207,313
India	1,028,289	461,763			

PRICES AND PRESENT UNITED STATES GOVERNMENT DOMESTIC MANGANESE PURCHASE PROGRAMS

Imported ore prices, based on ore containing 48 percent manganese delivered at eastern United States ports, duty paid, increased from approximately 72 cents per long ton unit (22.4 pounds of contained manganese) at the beginning of 1949 to $1.25 at the beginning of 1953. The price for domestic ore of the same grade, under Government purchase programs instituted in 1951 and 1952, was $2.30.

SUBSTITUTES

Although it is possible technically for certain elements to be substituted for manganese to give the desired results in its essential uses, none has proved to be adequately capable of replacing manganese on a production basis for the job it has to do. In fact, the substitution of manganese for certain other elements, which happen to be in even tighter supply, has progressed much further. The quantities of metal involved are small, however, compared to the quantities of manganese consumed in its normal uses.

CONSUMPTION OF MANGANESE ORE

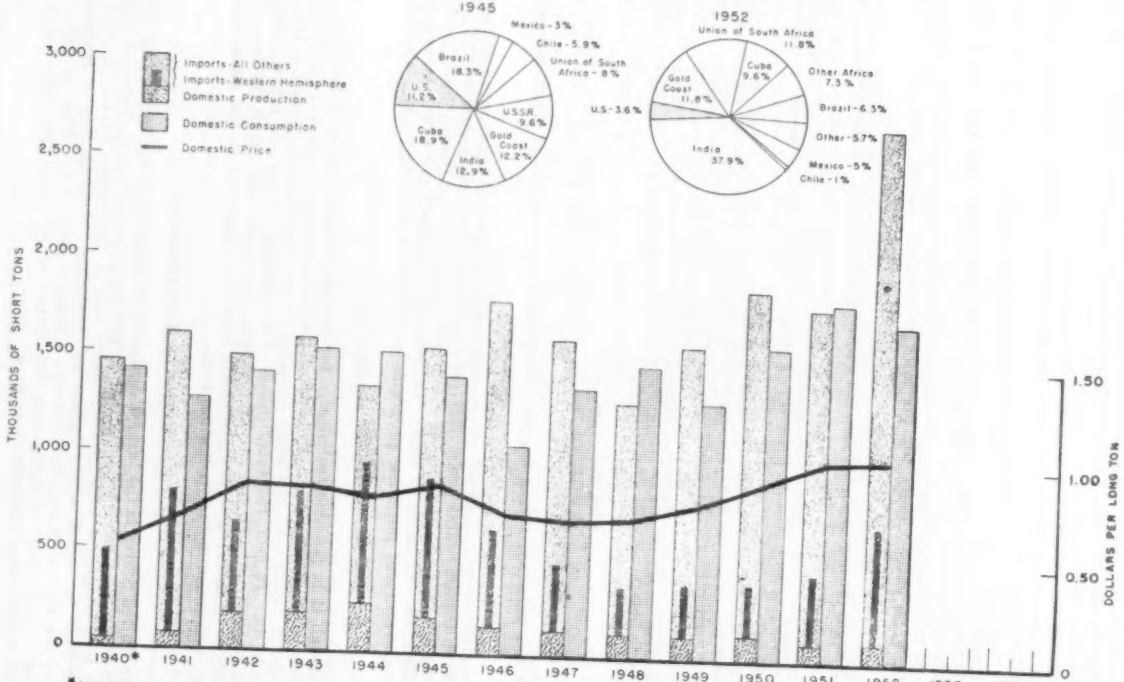
The United States is the largest consumer of manganese ore in the free world, followed by the United Kingdom which had an apparent consumption of 452,346 short tons compared with 2,050,651 short tons in the United States in 1950, the latest year for which world figures are available. Consumption of manganese ore in the United States in 1950 was 1,650,429 short tons. The combined apparent consumption of manganese ore in free-world countries, other than the United States, was 1,836,823 short tons.

Consumption of manganese, in terms of ore, in the United States, 1948–52

	Short tons, in terms of ore		*Short tons, in terms of ore*
1948	1,644,000	1951	2,121,000
1949	1,466,000	1952	1,945,000
1950	1,838,000		

SUPPLIES AND CONSUMPTION OF MANGANESE ORE, METALLURGICAL GRADE*

AVERAGE ANNUAL PRICE FOR IMPORTED ORES, BASIS 48 PERCENT MN.



* Includes some chemical grade.
* Consumption figure is estimated.

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 1

Prepared by United States Department of the Interior, Bureau of Mines

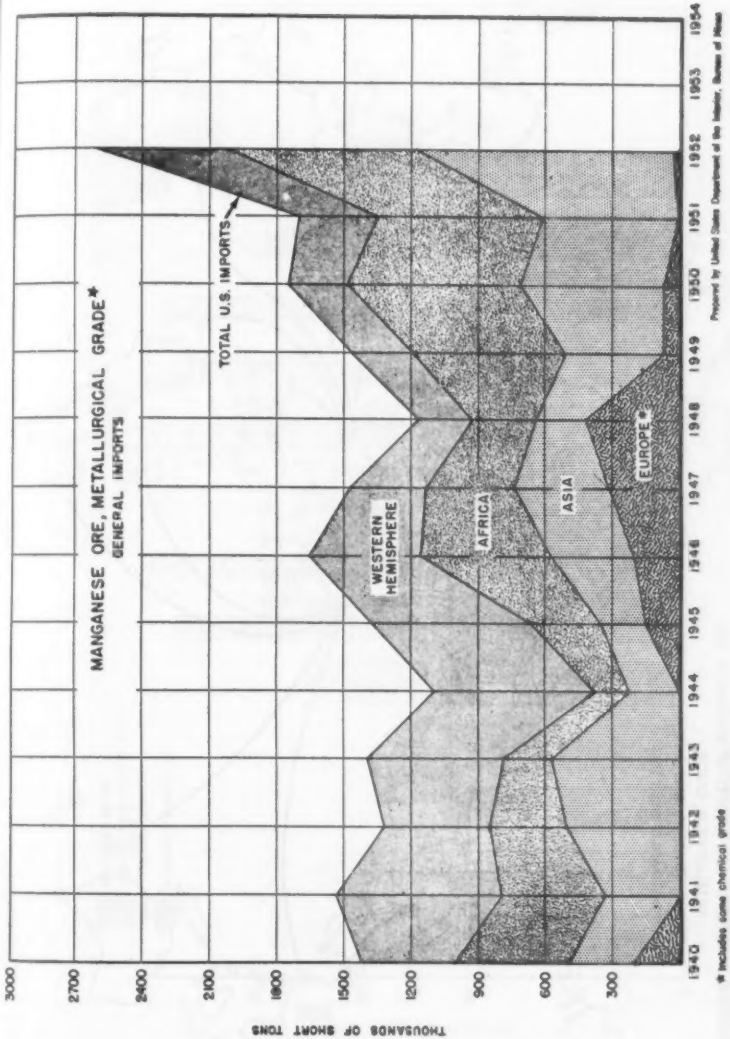

MANGANESE ORE, METALLURGICAL GRADE*
GENERAL IMPORTS
TOTAL U.S. IMPORTS
WESTERN HEMISPHERE
AFRICA
ASIA
EUROPE*
THOUSANDS OF SHORT TONS
3000
2700
2400
2100
1800
1500
1200
900
600
300
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
Prepared by United States Department of the Interior, Bureau of Mines
* Includes some chemical grade
* Includes 23,000 tons from Australasia, 1952.
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2

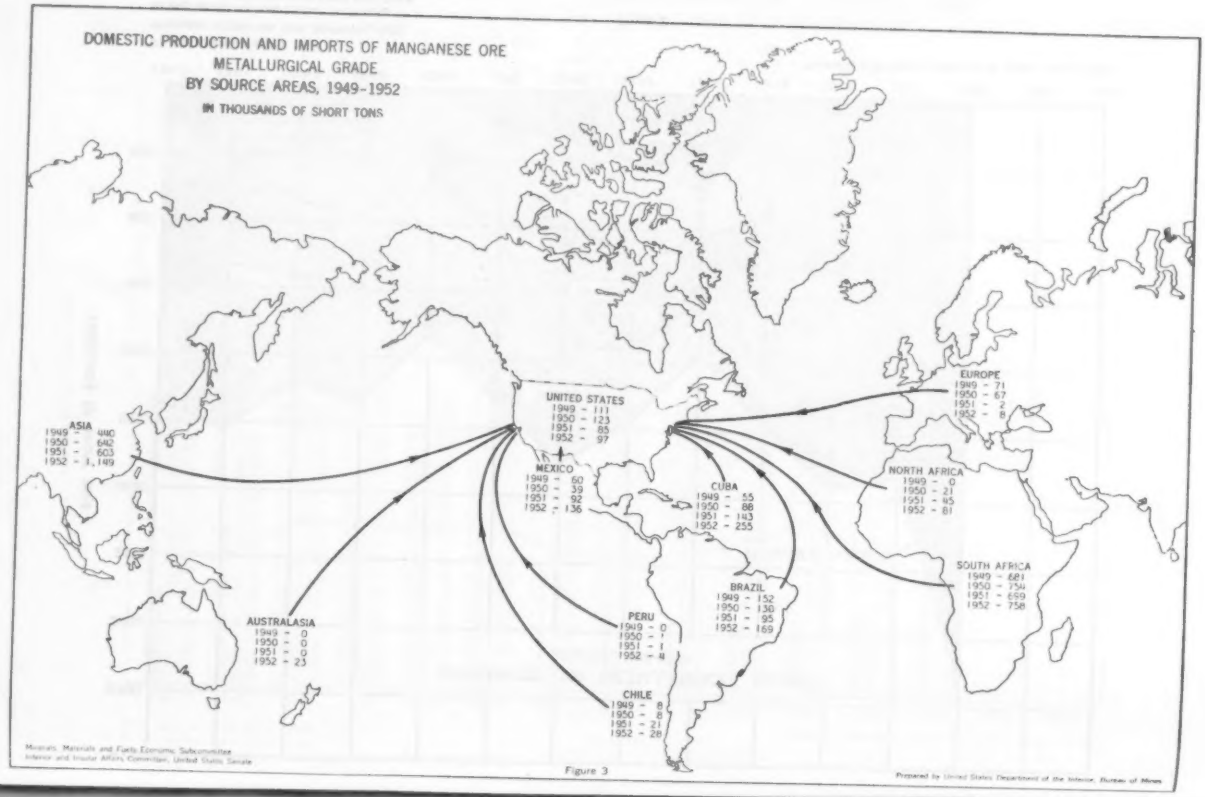
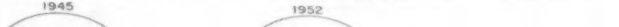


Figure 3

SUPPLIES AND CONSUMPTION OF MANGANESE ORE, BATTERY & CHEMICAL GRADES



SUPPLIES AND CONSUMPTION OF MANGANESE ORE, BATTERY & CHEMICAL GRADES

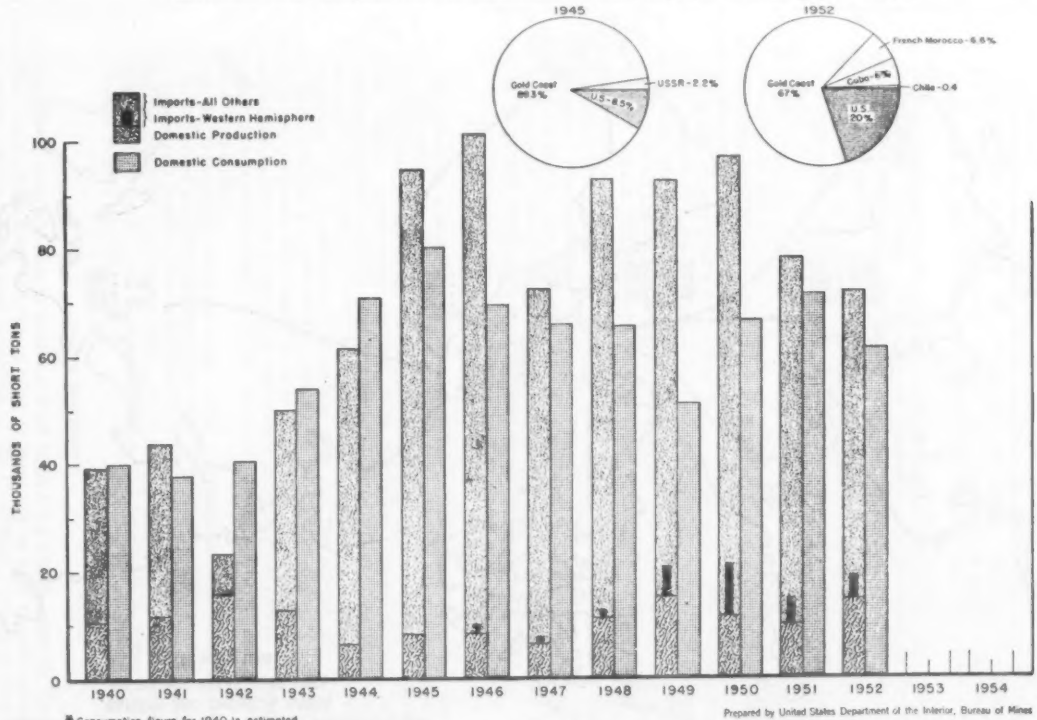
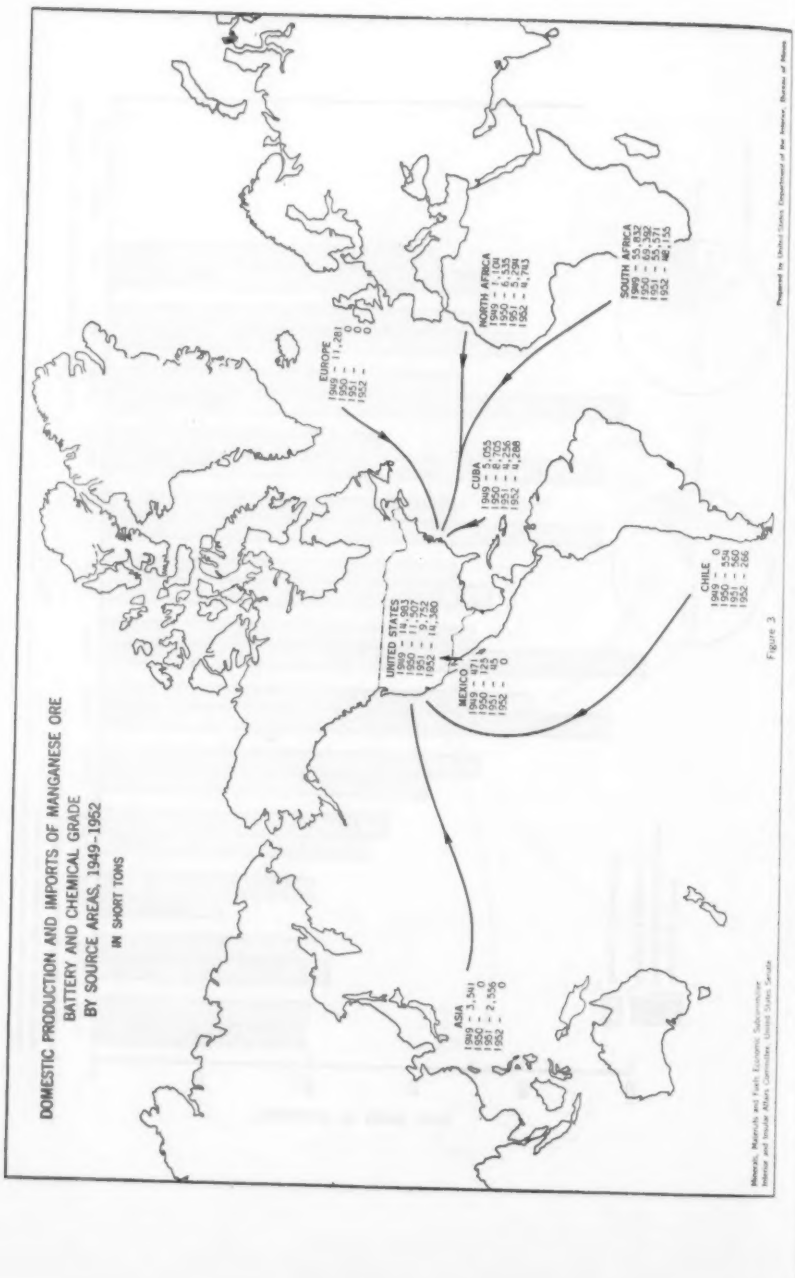


Figure 1


DOMESTIC PRODUCTION AND IMPORTS OF MANGANESE ORE
BATTERY AND CHEMICAL GRADE
BY SOURCE AREAS, 1949-1952
IN SHORT TONS
EUROPE
1949 = 11,281
1950 = 0
1951 = 0
1952 = 0
NORTH AFRICA
1949 = 1,104
1950 = 6,535
1951 = 5,539
1952 = 4,743
SOUTH AFRICA
1949 = 55,832
1950 = 69,392
1951 = 45,171
1952 = 48,135
CUBA
1949 = 7,055
1950 = 8,705
1951 = 9,256
1952 = 4,288
UNITED STATES
1949 = 14,503
1950 = 11,803
1951 = 9,752
1952 = 14,580
MEXICO
1949 = 121
1950 = 171
1951 = 45
1952 = 0
CHILE
1949 = 0
1950 = 550
1951 = 560
1952 = 266
ASIA
1949 = 3,541
1950 = 0
1951 = 0
1952 = 2,556
Figure 3
Minerals, Materials and Fuels Economic Subcommittee
Senate Public Works Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

The Molybdenum Position of the Western Hemisphere

Virtually all of the reserves of molybdenum ore in the world are in the Western Hemisphere, and if molybdenum-bearing material classed as ore only because it is a component of copper ores is discounted, nearly all these reserves are in North America. Molybdenum reserves of the United States contain more than 3 billion pounds of molybdenum metal. The Climax deposit in Colorado contains ore mined primarily for molybdenum; copper deposits of Nevada, New Mexico, and Utah contain molybdenum, both Canada and Mexico have significant ore reserves not completely developed. South American reserves are in copper ores. Norway, Japan, and Korea have small reserves. A deposit in Russia is said to have been developed, but no data on reserves are available.

The United States produces 88 percent of the world's molybdenum (excluding Russia); Chile provides 7 percent, and the balance is produced in Canada, Norway, Japan, and Peru. Mexico formerly produced molybdenum as a byproduct of copper mining.

At both molybdenum mines and at copper mines where molybdenum is produced as a byproduct a molybdenite (MoS_2) concentrate is produced. In the United States this concentrate is normally shipped to plants in Pennsylvania and Ohio for roasting and conversion to products used by industry; however, some is roasted at the mines. Chile and Canada ship unroasted concentrates.

The important molybdenum-consuming nations of Europe (excluding Russia) import concentrates for roasting and conversion to products. Nations that are small consumers import products, such as ferromolybdenum. The United States is the chief source of both concentrates and products; however, the European consumers also use the entire production of Chile and Norway, and in recent years have imported the small Canadian production.

The United States will continue to dominate the molybdenum industry for many years both as a producer of ore and of products. No large ore bodies are being developed outside the Western Hemisphere with the possible exception of Russia. Production in Canada will expand in the near future to about the level of Canadian requirements, but it is probable that firms in the United States will convert this material to products. The level of molybdenum production in Chile will continue to be dependent on the demand for copper.

UNITED STATES POSITION

Because potential emergency requirements for molybdenum exceeded the capacity of the producing firms the Government sponsored a plant expansion and mine development program at Climax, Colo., which is now nearly completed. Expanded copper production coupled with technical improvements in the molybdenum recovery units has contributed to the production of molybdenum. A purchase contract negotiated with a Canadian firm will add a small increment for stockpiling. If no emergency situation calls for the all-out use of molybdenum, there will be a considerable surplus of productive capacity; except for stockpiling requirements this would be true at present.

Increased production of alloy steels containing molybdenum can be expected in Europe and it is probable that an export demand for from 6 to 10 million pounds per year will continue.

In case an emergency develops after 1954, molybdenum will be available to substitute for other alloying elements that may be in short supply.

The long-termed demand for molybdenum in the United States can be expected to follow the trend of steel production. No significant change in the use pattern is expected. The supply from domestic sources will be ample to cover both the domestic and export requirements.

CANADA POSITION

Production of molybdenum is now confined to the La Corne mine in Quebec. Byproduct production from copper mining is expected to add to production in future years. In the recent past a portion of the Canadian production has been shipped to the United States for conversion to products needed in Canada and the balance has been exported to Europe. A portion of the future production may be purchased by the United States Government under the terms of an option to obtain up to 6 million pounds of molybdenite during the next 5 years. Production will be ample to cover the requirements of Canada.

CHILE POSITION

No new developments regarding molybdenum are known to be under way in Chile. Production will continue to be related to the output of copper at the Braden mine of Kennecott Copper Corp. From the long-term standpoint additional byproduct molybdenum may be available from other copper deposits.

NORWAY POSITION

The small production in Norway will become submarginal if there is a slight decrease in the world price for molybdenum.

CONSUMPTION OF MOLYBDENUM

The United States consumes 74 percent of the world's molybdenum. The other important consumers are United Kingdom, Germany, France, Sweden, and Canada.

World production of molybdenum in ores and concentrates, by countries, 1951–52 [1]

[In metric tons]

Country	1951	1952	Country	1951	1952
Australia	1	(2)	Peru	3	(3)
Austria	19	22	Sweden	2	(3)
Canada	104	135	United States	17,625	19,622
Chile	1,725	1,644	Yugoslavia	308	(3)
Japan	54	87			
Norway	125	122	Total (estimate)	20,500	22,200

[1] Molybdenum is also produced in North Korea, Rumania, Spain, and U. S. S. R. but production data are not available. Estimates are included in total.
[2] Less than 0.5 ton.
[3] Data not available, estimate included in total.

Consumption of molybdenum in the United States, 1948–52

	Thousands of pounds, molybdenum content		*Thousands of pounds, molybdenum content*
1948	25,156	1951	33,691
1949	19,960	1952	32,715
1950	26,029		

ALLOCATION OF MOLYBDENUM

The International Materials Conference issued plans of distribution of molybdenum, which had been approved by member nations, during the period from July 1, 1951, to July 1, 1953. In 1952 the United States was allocated 76 percent of the total estimated supply.

Summary of International Materials Conference distribution of molybdenum in 1952

[Metric tons of metal content]

Nation	Concentrates	Primary products [1]	Nation	Concentrates	Primary products [1]
Argentina		0.52	Netherlands	17.00	16.50
Australia		85.00	New Zealand		12.37
Austria	17.50	76.50	Norway		11.00
Belgium		96.00	Portugal		8.00
Brazil		20.20	South Africa		22.50
Canada		375.50	Spain		33.50
Chile	1.00	3.00	Sweden	468.00	12.00
Denmark		6.00	Switzerland	4.00	49.00
Finland		10.00	Turkey		9.50
Formosa		.50	United Kingdom	2,215.50	
France	1,217.00		United States	16,121.60	
Germany	972.95		Yugoslavia		10.50
India		4.00	Reserve	7.95	
Italy	78.50	104.00			
Japan	225.00		Total estimated production	21,346.00	
Mexico		.85	Total distribution of products		966.94

[1] Raw material to produce these products is included in the concentrate column.

The Cobalt Position of the Western Hemisphere

Cobalt occupies a unique position among the commercially and technically important metals. Compared with nickel, it is not used in large tonnages, but it is essential to a number of technical operations in present-day manufacture. The strategic importance of cobalt lies in its use, chiefly as an alloying element, in high-temperature alloys, high-speed cutting tools, and high-performance magnetic alloys. The ability of cobalt-base alloys to withstand high temperatures has made them superior to other alloys in jet aircraft engines and turbosuperchargers and for various components of gas turbines. The cutting efficiency of high-speed steels is almost directly proportional to their cobalt content. A similar relationship exists between cobalt content and magnetic efficiency in permanent-magnet alloys.

Belgian Congo, on which the United States has depended for most of its cobalt supply, has the largest and richest commercial reserves and has modern refineries in Belgian Congo, Belgium, and the United States. Accordingly, it will continue to rank first as a producer of cobalt for many years in the future.

Despite the large potential reserves of cobalt in the United States, lack of metallurgical extraction methods has prevented the country from becoming an important producer. In processing from ore to refined metal, few metals require such diversity of metallurgical operations as does cobalt. Provided processes developed for extracting cobalt contained in the ores at two deposits attain scheduled production rates, the United States will have capacity to produce about 5,300,000 pounds annually, which is greater than consumption in any year previous to 1950, but is not enough to meet mobilization requirements.

A large strategic stockpile of cobalt would make possible the meeting of mobilization demand in the event supplies were cut off from Belgian Congo.

RESERVES

Virtually all cobalt occurs in combination with other metals, such as copper, nickel, iron, arsenic, lead, zinc, manganese, silver, and gold. Seldom does cobalt occur in sufficient quantity to be mined for cobalt alone. Consequently, the main sources of cobalt are as coproducts or byproducts in the production of other metals.

Associated with other metals, there are huge reserves of cobalt in the Western Hemisphere, and were recovery practicable production would probably be adequate to supply the United States. However, large quantities of the cobalt contained in the ores mined in the United States, Canada, and Cuba are not being recovered as a separate product.

Heretofore, the United States has been a relatively small producer of cobalt ore and concentrates. The most promising deposits containing cobalt in the United States have now been developed and should the process developed for refining the ores attain scheduled production rates, the United States will have capacity to produce cobalt at annual rate of about 5,300,000 pounds, a quantity slightly in excess of United States consumption in 1948. Recent exploration in the Blackbird district of Idaho has indicated promising reserves of cobalt.

Increased production of cobalt by two companies in Canada and initial production by a third company will add substantially to the supply in 1954. However, despite the large potential reserve of cobalt in the nickel-copper ore in the Sudbury district of Canada, because complete recovery does not appear to be practicable, output will continue at a relatively low level.

Because the nickeliferrous iron ores of eastern Cuba are the world's largest potential sources of nickel, with which is associated cobalt, the Cuban deposits offer a good opportunity to augment the world supply of cobalt. However, no process has been developed for separating the cobalt, much of which is lost.

A substantial quantity of cobalt could probably be recovered from the converter slag at Sta. Rosalia, Baja California, and the copper-lead ores of eastern Missouri should methods be developed for recovering the cobalt.

UNITED STATES POSITION

The measured, indicated, and inferred reserves of cobalt in the United States have been estimated by the Bureau of Mines and the Geological Survey at about 196,000 short tons (cobalt content). The most important reserves are at Cornwall, Pa., Fredericktown, Mo., and the Blackbird district, Idaho, and are estimated at 89,000 tons. These deposits have been developed for mining and those at Cornwall, Pa., and the Blackbird district, Idaho, are served by refineries. A

refinery, designed to produce 1,386,000 pounds of cobalt annually, is being erected to serve the deposits at Fredericktown, Mo. The refining process used on the Blackbird ore and to be used on the Fredericktown ore is completely new. Because of mechanical difficulties and the failure of parts and equipment to withstand the corrosive and abrasive conditions to which they were subject, continuous operation of the refinery serving the Blackbird ore has been impossible. Consequently, thus far the quantity of refined cobalt produced has been small relative to the designed capacity of the plant, which is 3,300,000 pounds. However, should the problem of refining the ores from the Blackbird district and at Fredericktown be solved, the United States will have annual capacity to produce about 5,300,000 pounds of cobalt from domestic ore by the end of 1953.

Despite the fact that deposits of cobalt elsewhere in the United States contain larger reserves (107,000 tons), the problem of recovering the cobalt by present methods of treating the ores has not been solved. Moreover, some of the ores, for example, the sulfide ores in the Appalachian region, contain only a few hundredths to 0.1 percent cobalt. In general, these deposits are well scattered, small, and shallow, and many of the deposits would not justify a concentrator or refinery.

CANADA POSITION

Cobalt is found in Canada associated with the silver ores at Cobalt, Ontario, with the nickel-copper ores of the Sudbury district, Ontario, and Lynn Lake area, Manitoba, and with pitchblende at Port Radium, Northwest Territory. Complete information on reserves is not available, but Vhay, of the United States Geological Survey, has estimated the reserves of recoverable cobalt at Sudbury and Cobalt at 260 million pounds. By far the larger reserves are in the Sudbury district, where the nickel-copper ores have been estimated to contain 0.06 to 0.1 percent cobalt. Both the International Nickel Co. of Canada, Ltd., and Falconbridge Nickel Mines, Ltd., recover some of the cobalt contained in the ore mined in the Sudbury district. However, no attempt is made to recover all the cobalt, as evidenced by the fact that the refined nickel produced contains about 1 percent cobalt. The large tonnage of Sudbury district nickel-copper ores treated would, if complete recovery of cobalt were practicable, place this source among the front rank of world cobalt producers. Beginning 1953 cobalt will be recovered from the nickel-copper ore of the Lynn Lake area in northern Manitoba by Sherritt Gordon Mines, Ltd.; planned annual production is 300,000 pounds.

Before the International Nickel Co. began production of cobalt in 1947, the mines in northern Ontario near Cobalt, where the cobalt is associated with silver, were the chief producers. Subsequently, output from the Sudbury district has exceeded that of northern Ontario. The Deloro Smelting & Refining Co., Ltd., has a refinery at Deloro, Ont., and Quebec Metallurgical Industries, Ltd., is constructing a smelting and refining plant at Cobalt, Ont.

MEXICO POSITION

Cobalt has been found at many places in Mexico but has been produced from only a few. Information on reserves is not available. The copper ore mined by Boleo Copper Co., Sta. Rosalia, Baja California, contains about 0.3 percent cobalt. The converter slag contains 2 to 4 percent cobalt and an alloy containing about 20 percent cobalt is reported to build up in the reverberatories. At the annual rate of 200,000 metric tons of ore treated, possibly 600,000 pounds of cobalt might be produced if a metalludgical extraction method could be developed.

CUBA POSITION

The nickeliferous iron ores of eastern Cuba are a large potential source of cobalt. These deposits are estimated to contain at least 3 billion tons of ore containing a little cobalt. Thus far only the deposits in the Levisa Bay area have been mined for nickel but no attempt has been made to recover the cobalt as a separate product. However, a pilot plant has been installed with the view of

developing a process to separate the nickel and cobalt. The reserves of ore in the Levisa Bay area have been estimated to average 0.075 percent cobalt. Currently, somewhat in excess of 1 million tons of ore from this area are being treated at the Nicaro plant annually for the production of nickel oxide. Assuming a recovery of 60 percent, it is estimated that about 900,000 pounds of cobalt is being lost annually. The largest reserve of nickeliferous iron ore is in the Mayari district, but the ore is less rich in cobalt and nickel than that in the Levisa Bay area. Second to the Mayari district in importance is the Moa Bay area, where the Freeport Sulphur Co. recently announced the discovery of a large deposit of ore averaging about 1.35 percent nickel and 0.14 percent cobalt. The deposits in Cuba possibly contain over a million tons of cobalt.

SOUTH AMERICA POSITION

Occurrences of cobalt are found in several countries in South America but production has been reported only in Argentina, Bolivia, Brazil, and Chile. However, production has been very small.

ARGENTINA POSITION

Cobalt is found at the Rema Alejandra mine near Vinchima, La Rioja Province and some ore was produced before 1904.

BRAZIL POSITION

Cobaltiferous manganese-iron-oxide "pebbles" occur in the ferruginous clay overlying the nickel silicate deposits near São José do Tocantins, Goias. During 1939–41 about 450 metric tons of ore containing 3 to 5 percent cobalt were shipped to Japan. It has been estimated that the deposits in this area contain about 4 million tons of ore averaging 0.28 to 0.4 percent cobalt.

CHILE POSITION

Cobalt occurrences have been reported at many places and it has been mined from time to time at several localities in Chile but total production has been small. Several years ago an attempt was made to work a deposit of low-grade ore in Freirina; and a concentrating plant for improving the grade of the ore was installed. Judged by the small output the operation was not successful.

VENEZUELA POSITION

Large deposits of nickel-silicate ore containing a little cobalt have been found a Loma de Hierro. Data on ore reserves have not been published, but press notes have indicated that reserves exceed 30 million tons, averaging about 1.75 percent nickel.

AFRICA POSITION

The Belgian Congo has the largest and richest commercial reserves of cobalt. On the basis of a rate of production of 6,000 metric tons annually, the Union Minière du Haut-Katanga, the sole producer, reports reserves of cobalt adequate for about 40 years, and it anticipates that these reserves will increase as a result of further development of its copper deposits. Production reached an all-time high of 6,831 metric tons in 1952, or 68 percent of world total.

The reserves of cobalt in Northern Rhodesia have been estimated at 225 million pounds, but percentage of recovery is not reported. The Rhokana Corp., the sole producer, began production of cobalt metal in August 1952 at its new electrolytic refinery, which is designed to produce 3 million pounds annually.

Inferred reserves in French Morocco have been estimated at about 28 million pounds of cobalt.

SOURCES OF SUPPLY FOR UNITED STATES

As shown in the following table, the Belgian Congo is by far the chief source of supply of cobalt for the United States. In 1952 Belgian Congo furnished about 90 percent of the total supply.

Cobalt produced in and imported into the United States in 1948–52, in pounds of cobalt

Year	Domestic production	Imports into United States					
		Canada	Mexico	Europe	French Morocco	Belgian Congo	Total
1948	687,464	870,519	.....	324	.....	7,950,586	8,821,000
1949	521,656	11,817	.....	11,260	.....	7,434,591	7,458,000
1950	809,328	19,562	.....	30,326	.....	9,045,581	9,095,000
1951	902,629	40,321	3,825	6,712	179,046	10,107,929	10,338,000
1952	1,363,251	6,630	17,415	2,135	345,300	14,659,339	15,031,000

TARIFF

The duty on cobalt oxide is 5 cents a pound, sulfate 2½ cents a pound, linoleate 5 cents, and other salts and compounds 30 percent ad valorem. Cobalt metal and ore enter the United States duty free.

CONSUMPTION OF COBALT

The United States is the largest consumer of cobalt in the world. The largest foreign user is the United Kingdom, which consumed 2,251,000 pounds in 1950—the latest year for which figures are available.

Consumption of cobalt in the United States, 1948–52

	Contained cobalt, pounds		*Contained cobalt, pounds*
1948	5,019,224	1951	9,932,993
1949	4,701,926	1952	10,818,493
1950	8,283,408		

FREE-WORLD PRODUCTION

Currently the free-world supply of cobalt is being furnished chiefly by Belgian Congo, Canada, French Morocco, Northern Rhodesia, and the United States. The Belgian Congo has for many years been the predominant producer and will probably continue to rank first for many years in the future.

Free-world mine production of cobalt, by countries, in 1951 and 1952

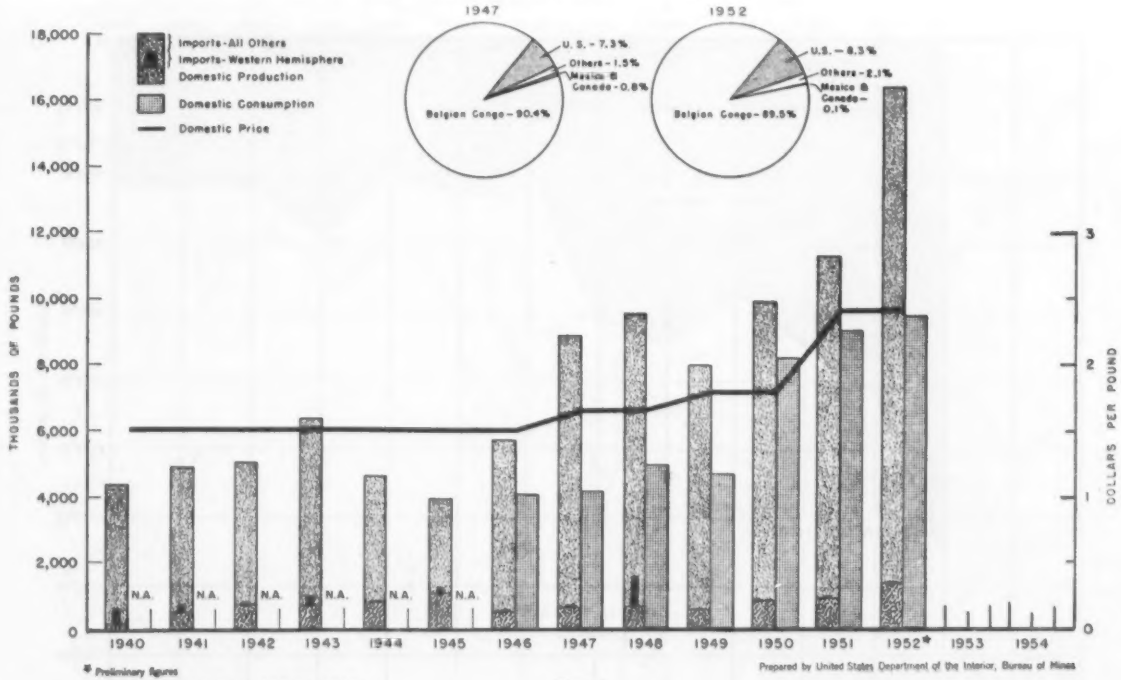
Country	1951		1952	
	Metric tons of contained cobalt	Percent of total	Metric tons of contained cobalt	Percent of total
Belgian Congo	5,715	68.86	6,831	68.31
Canada [1]	432	5.20	592	5.92
Mexico (content of ore) [2]	2		8	
Morocco, French (content of concentrates)	680	8.19	1,000	10.00
Northern Rhodesia (content of white alloy)	678	8.17	585	5.85
United States (shipments) (content of concentrates)	343	4.13	379	3.79
Undistributed	400	4.82	600	6.00
Total	8,300	100.00	10,000	100.00

[1] Figures comprise Canadian ore processed in Canada and exported (irrespective of year when mined) plus cobalt content of concentrates made at Port Colborne from copper-nickel ore. However, figures exclude the cobalt recovered at Clydach, Wales, from Canadian nickel-copper ores, for which estimate has been included in undistributed.

[2] Imports into United States.

SUPPLIES AND CONSUMPTION OF COBALT
YEAR END PRICES PER POUND OF COBALT METAL
1947
1952

SUPPLIES AND CONSUMPTION OF COBALT
YEAR END PRICES PER POUND OF COBALT METAL



* Preliminary figures

N.A. Figures not available 1940 thru 1945.

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 1

TIGH
BOU
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
THOUSANDS OF POUNDS
1940
1941
1942
1943
1944
OTHER
*Due to German occupation of France 1,000,532 lbs. in
were shipped to the United States
in 1945. 430,300 lbs. were seized by U.S. Army in ea

HTLY

UND

DOMESTIC PRODUCTION AND IMPORTS OF COBA
BY SOURCE AREAS, 1949-1952
IN THOUSANDS OF POUNDS

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

* Refined or Concess from A

Figure 3

Prepared by United States Department of the Interior, Bureau of Mines

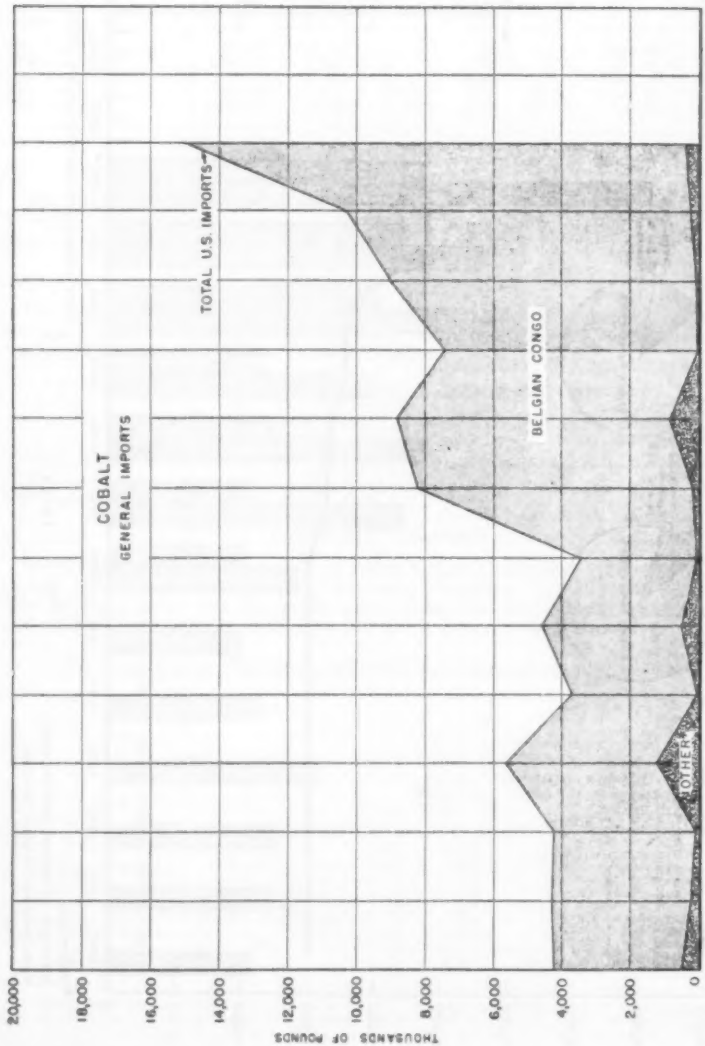

COBALT
GENERAL IMPORTS
TOTAL U.S. IMPORTS
BELGIAN CONGO
OTHER*
THOUSANDS OF POUNDS
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
Prepared by United States Department of the Interior, Bureau of Mines
*Due to German occupation of France 1,000,532 lbs. in 1943 and 26,413 lbs. in 1944 were shipped to the United States
In 1945 430,300 lbs. were seized by U.S. Army in occupation of Germany

Figure 2

were shipped to the United States
In 1945 430,3001bs. were seized by U.S. Army in occupation of Germany.

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2

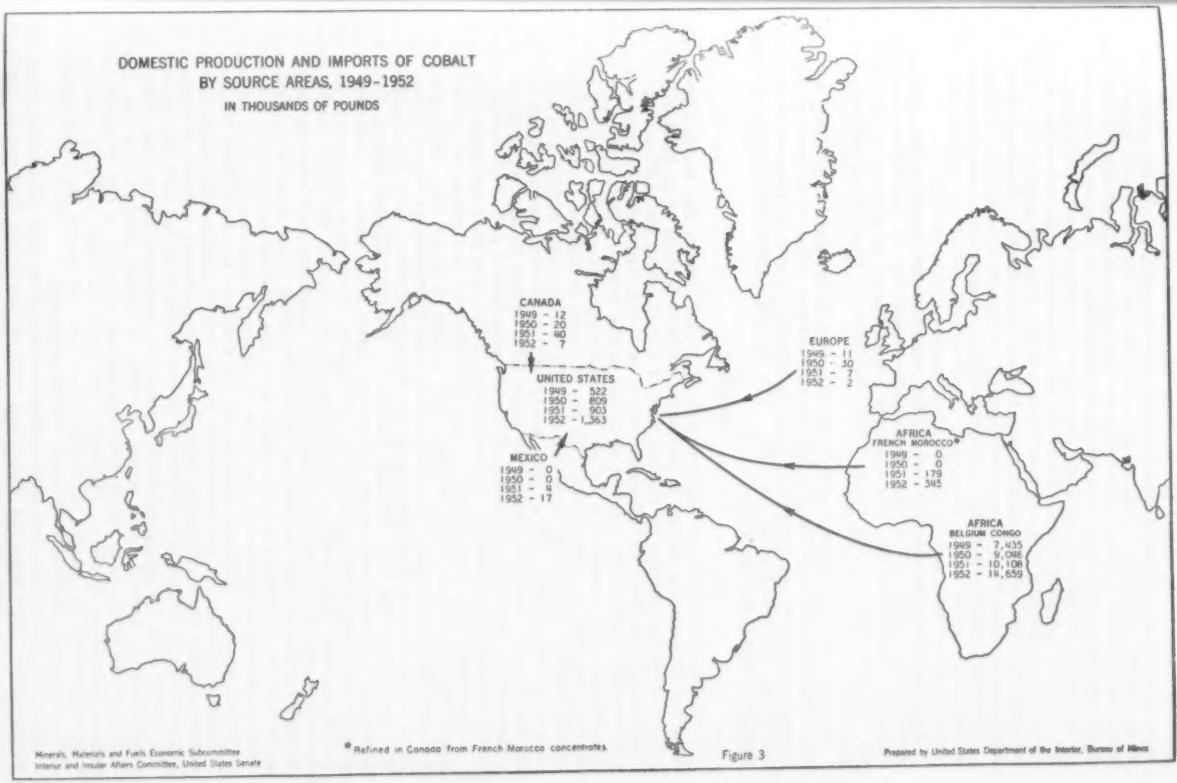


Figure 3

The Nickel Position of the Western Hemisphere

Ever since the superiority of armorplate made from nickel steel was discovered about 1889, nickel has been an important alloying element in the construction of war materiel, where qualities of strength, toughness, and resistance to corrosion, wear, and heat, as well as other special and useful properties are required. Nickel is also a metal of peace and some of the greatest developments in its use have been in the things of everyday life. Indicative of the versatility of nickel is that over 3,000 alloys in current use contain a fraction to something less than 100 percent nickel. Facilities for production, although ample for peacetime, are inadequate to meet mobilization needs, and new sources have to be developed and additional smelting and refining plants built. Production capacity adequate to meet wartime needs is greatly in excess of peacetime requirements.

Expansion of existing production facilities now under way and facilities being installed to serve newly developed deposits will result in capacity in North America to produce nearly 200,000 short tons of nickel in 1956.

A large strategic stockpile of nickel would make possible the meeting of mobilization demand without inordinate expansion of peacetime production capacity. Unfortunately, the stockpile accumulation at present is far short of its objective and, consequently, large expansion of production and capacity is necessary.

Canada not only dominates nickel production at present but is likely to maintain that position for many years because of the richness in both nickel and copper and enormous reserves. Canada supplied about 86 percent of the free-world production of nickel in 1952. The United States, the largest consumer, produced less than 1 percent.

RESERVES

Probably two-thirds of the reserves of nickel ore in the world are in the Western Hemisphere, which is estimated to have a total of at least 3½ billion tons containing perhaps 30 million tons of nickel. And about 97 percent of the reserves of the Western Hemisphere are in North America. However, despite the enormous potential reserves of nickel in the Western Hemisphere, economic ore deposits are exceedingly rare. A notable exception is the Sudbury district in Ontario and the Lynn Lake area in northern Manitoba, Canada, where the sulfide deposits have large reserves, are rich in nickel and copper, and also carry important byproducts. Elsewhere, many of the reserves are small, are less rich in nickel, and most are lacking in important values in byproduct metals and, consequently, operation at many of the deposits would not be economic and for other deposits processes for the treatment of the ores have not been developed.

Accordingly, the nickel industry has been centered in Canada, which for many years has supplied the bulk of the world supply of nickel ore. Both the International Nickel Company of Canada, Ltd., and Falconbridge Nickel Mines, Ltd., have large reserves of sulfide ore in the Sudbury district, have developed mines, and have smelting and refining facilities. Sherritt Gordon Mines, Ltd., has substantial reserves of sulfide ore in the Lynn Lake area, a developed mine, and is installing refining facilities. Moreover, there is a possibility that the newly discovered deposits of sulfide ore in the Yukon Territory might prove large enough to warrant establishment of smelting and refining facilities. Therefore, despite the increase in production from other sources, Canada will, as heretofore, continue for many years to be the predominant producing country.

Because the nickeliferous iron ores of eastern Cuba are the world's largest potential sources of nickel, because of its nearness to the United States, and because a process for the conversion of the ore to commercial oxide has been developed, the Cuban deposits offer the best opportunity outside of Canada to augment the world supply of nickel. Nevertheless, thus far only the deposits in the Levisa area are equipped with a plant for treatment of the ore. The plant is at Nicaro. Except for a small quantity of nickel produced in the United States, Cuba is the only other nickel-producing country in the Western Hemisphere outside of Canada. Currently, the plant in Cuba is being operated at capacity, which is 14,000 to 15,000 short tons of nickel in oxide annually. Beginning early 1954 sintered oxide will be produced.

Although the Cuban ores also contain cobalt, iron, and chromium, thus far at the Nicaro plant only the nickel and some of the cobalt (but not as separate products) have been recovered. Profitable exploitation of the Cuban ores will depend upon the economic recovery of all the valuable constitutents. A pilot plant is now in operation with the view to developing a process to separate the nickel and cobalt. An economic process for the conversion of oxide to metal

has been developed by the Bureau of Mines. The Bureau of Mines is now conducting metallurgical studies to develop an improved and lower cost method of extraction of nickel and for recovering the associated cobalt, chromium, and iron.

The geographical remoteness of the Tocantins deposits in Brazil, the scarcity of labor, and the excessive cost of power, fuel, and freight are factors which preclude their economic exploitation.

Although the deposits of nickel silicate ore at Loma de Hierro, Venezuela, are reported to be large and are favorable for mechanized mining by open pit, the ore cannot be treated economically by current smelting practice.

As for the United States, there is little hope for it to become an important producer of nickel, unless an economic and feasible method is developed for recovering the nickel in low-grade nickeliferous iron ores and unless further exploration of certain sulfide deposit should disclose substantially larger reserves.

Production of nickel ore in 1952 and estimated reserves of nickel ore in the Western Hemisphere

[In short tons]

	Production of nickel ore in 1952	Equipped or being equipped for smelting and refining		Unequipped	
		Ore	Nickel content	Ore	Nickel content
North America:					
United States:					
Continental:					
Riddle, Oreg.		17,000,000	257,000		
Fredericktown, Mo.		[1] 1,775,000	[1] 8,500		
Other				37,475,000	204,000
Alaska				22,000,000	70,000
Total		18,775,000	265,500	59,475,000	274,000
Canada:					
International Nickel Co. of Canada, Ltd.	13,248,593	256,356,000	4,000,000		
Falconbridge Nickel Mines, Ltd.	1,112,856	32,987,000	538,000		
Sherritt Gordon Mines, Ltd.		14,055,000	172,000		
Other	10,635			2,750,000	45,000
Total	14,372,084	303,398,000	4,710,000	2,750,000	45,000
Cuba:					
Levisa	917,000	27,700,000	400,000		
Mayari, Moa Bay, and San Felipe				3,000,000,000	24,000,000
Total	917,000	27,700,000	400,000	3,000,000,000	24,000,000
Total North America	917,000	349,873,000	5,375,500	3,062,225,000	24,319,000
South America:					
Brazil:					
Tocantins, Goias				10,000,000 to 18,000,000	200,000 to 360,000
Livramento and Ipanema, Minas Gerais				4,000,000	40,000
Total				14,000,000 to 18,000,000	240,000 to 400,000
Venezuela				30,000,000 to 50,000,000	450,000 to 875,000
Total South America				44,000,000 to 68,000,000	690,000 to 1,275,000
Total Western Hemisphere	15,289,084	349,873,000	5,375,500	3,106,225,000 to 3,130,225,000	25,009,000 to 25,594,000

[1] Measured and indicated. Company data indicate substantially larger reserves and inferred reserves probably total several times measured and indicated.

UNITED STATES POSITION

Currently, the United States is producing a few hundred tons of new nickel, which is less than 1 percent of its requirements. This unfavorable position will be improved somewhat when the two most important deposits in tonnage and grade, the sulfide-ore deposit at Fredericktown, Mo., and the silicate-ore deposit at Riddle, Oreg., are brought into production. Planned annual production at the Fredericktown operation, which is expected to begin the latter part of 1953, is 926 short tons. Projected annual production at the Riddle operation is 7,000 to 9,000 tons of nickel contained in ferronickel and initial production is expected late in 1954.

The other higher grade sulfide ores are found in small bodies in widely separated parts of the country. Most of them are small and expensive to explore; and they are too few to warrant establishment of a smelting industry. The larger bodies contain scarcely more than a few hundred tons of nickel in ore whose average grade is 1 to 3 percent. The potentially more important sulfide deposits are those at Yakobi Island, Alaska, and at Mouat, Mont., in which the larger and better grade bodies have an average nickel content of 0.4 percent.

The other deposits of silicate ore are much smaller in tonnage and lower in grade than the deposit at Riddle, Oreg.

The potential tonnage of nickeliferous iron ores at Cle Elum, Wash., and elsewhere in the United States is large but the grade is low, and an economic and feasible method of recovery of the nickel has not been developed.

Accordingly, although the total reserves of sulfide and nickeliferous ores are substantial, there is little hope that the unfavorable position of the United States with respect to production of nickel could be improved unless further exploration of certain sulfide deposits should disclose substantially larger reserves and an economic process is developed for treatment of extremely low-grade nickeliferous ore.

Therefore, despite the potential increase in domestic production, the United States will continue to be dependent on foreign sources for 90 percent or more of its supply of new nickel.

CANADA POSITION

At present the nickel industry is centered chiefly in the Sudbury district in Ontario, Canada, which for many years has supplied the bulk of the world supply of nickel ore. The International Nickel Co. of Canada, Ltd., operates five mines in the Sudbury district, smelters at Copper Cliff and Coniston, Ontario, and refineries at Port Colborne, Ontario, Clydach, Wales, and Huntington, W. Va. The Falconbridge Nickel Mines, Ltd., operates two mines in the Sudbury district, a smelter at Falconbridge, Ontario, and a refinery at Kristiansand, Norway. Both of the concerns are expanding production facilities. The East Rim and Milnet mines, also in the Sundbury district, were brought into production in 1952.

The refinery of Sherritt Gordon Mines, Ltd., at Fort Saskatchewan, Alberta, which will treat ore from Lynn Lake, Manitoba, is scheduled for completion in December 1953. Annual planned production from company ore is 8,500 tons. The Sherritt Gordon Mines, Ltd., has taken a small participation in Western Nickel, Ltd., which has acquired a nickel property at Choate, British Columbia. Western Nickel, Ltd., has concluded a contract with Defense Materials Procurement Agency to deliver nickel to the United States Government. The concentrates produced will probably be refined by Sherritt Gordon.

With completion of these expansion programs it is estimated that equipped mines in Canada will have capacity to produce about 174,000 short tons of nickel.

The largest reserves of developed sulfide ores of nickel in the world are those of the Sudbury district of Canada. As of December 31, 1952, the proved ore reserves of the International Nickel Co. of Canada, Ltd., were 256,356,000 short tons containing 7,795,000 tons of nickel-copper, and the developed and indicated reserves of Falconbridge Nickel Mines, Ltd., were 32,987,000 tons containing 538,000 tons of nickel. At the 1952 rate of production the reserves of these two companies were sufficient for 19 and 30 years, respectively.

Probably the second largest reserves of sulfide ores of nickel are in the Lynn Lake area of northern Manitoba, where Sherritt Gordon Mines, Ltd., and other companies have holdings. The small amount of exploration done by Sherritt Gordon indicated ore reserves of 14,055,000 tons containing 172,000 tons of nickel.

A new nickel-producing area might result from recent discoveries of sulfide ore in the Yukon Territory. Too little exploration has been done to determine the extent of the reserves, but the limited drilling done has revealed ore of high grade.

CUBA POSITION

The Cuban Nickel Co., a United States Government corporation, owns a nickel-producing plant and townsite at Nicaro, Cuba. The plant was completed and began operating in late 1943. Operation ceased March 31, 1947. Meanwhile, 3,323,075 dry short tons of ore containing 91,702,615 pounds of nickel were processed, from which 82,735,148 pounds of oxide containing 63,571,414 pounds of nickel plus cobalt were recovered. The plant has an annual capacity of about 15,000 short tons of nickel.

Rehabilitation of the plant was started early in 1951 and 4 of the 12 furnaces were put into operation January 31, 1952. The last two furnaces were put into operation July 7. During the year 11,604 tons of oxide containing 8,958 tons of nickel plus cobalt were produced.

The nickeliferous iron ores of eastern Cuba are the world's largest potential sources of nickel. These deposits are estimated to total at least 3 billion tons of ore containing about 24 million tons of nickel. However, the average low content of nickel in the deposits, combined with the finely divided distribution of the nickel in an iron-rich material, has made it relatively costly to obtain a product of high nickel content. Nevertheless the nearness of Cuba to the Atlantic seaboard and the Gulf ports of the United States gives it importance as a source of nickel.

The Cuban deposits offered the best opportunity to augment the world supply of nickel in World War II and the United States Government erected a plant at Nicaro to produce nickel oxide. Ore for the plant was supplied from deposits in the vicinity of Levisa Bay, approximately 8½ miles by rail from the plant. Currently, ore from these deposits is being used. As of June 30, 1945, the total ore reserves of the Levisa group were estimated at 31 million tons averaging 1.39 percent nickel.

Competition of Cuban nickel with that of Canada is handicapped by the fact that Canadian ore contains many commercial byproducts which the Nicaro ore does not have, such as copper, platinum metals, gold, silver, selenium, and tellurium, which are simultaneously recovered with the nickel. Although the Nicaro ore also contains cobalt, iron, and chormium, thus far only the nickel and some of the cobalt, but not as separate products, have been recovered. A pilot plant has been installed with the view of developing a process to separate the nickel and cobalt. A sintering plant is under construction at Nicaro; completion is scheduled about December 31, 1953. An economic process for the conversion of oxide to metal has been developed by the Bureau of Mines, but no decision has yet been reached concerning the erection of a reduction unit.

Profitable exploitation of the nickel-bearing iron ores of Cuba will depend on the economic recovery of all the valuable constituents. The Bureau of Mines is conducting metallurgical studies to develop an improved and lower-cost method of extraction of nickel and for recovering the associated cobalt, chromium, and iron from the laterite and serpentine ores. The ore going to the Nicaro plant in June 1952 contained 1.38 percent nickel, 0.1 percent cobalt, 38 percent iron, and probably 1½ percent Cr_2O_3. If all these valuable constituents could be recovered, the gross value would be nearly $24 a dry short ton.

The nickeliferous iron-ore deposits in the Mayari district contain the largest reserve of nickel in the world. Indeed, the deposits contain enough nickel to supply the world at an annual rate of production of 175,000 tons for at least 50 years, provided an economic process could be developed for recovering the nickel. The deposits hre about 1,600 feet above sea level on a plateau about 20 miles from the coast. The ore lies at the surface with no overburden. It contains, on a dry basis, slightly less than 1 percent nickel, about 49 percent iron, 3 percent chrome, and a little cobalt. The Bethlehem Steel Co. has made a persistent effort to utilize the deposits as a source of iron ore. However, as the nickel and chromium remain with the iron, the sale and use of iron and steel made from the ore has been strictly limited.

The deposits in the Moa Bay area are next in importance to the Mayari deposits. The Moa Bay deposits are about 65 miles east of the Levisa Bay deposits and only a few miles from tidewater. The Moa Bay ore contains more nickel and less iron than the Mayari ore. Discovery of a large deposit of nickel ore as a result of extensive exploration recently completed in the Moa Bay area was announced by Freeport Sulphur Co. The deposit is reported to contain at least 40 million tons of ore averaging about 1.35 percent nickel and 0.14 percent cobalt. The Freeport Sulphur Co. hopes to be in commercial production of nickel in 1955, with a minimum initial output of 30 million pounds annually.

BRAZIL POSITION

Approximately 50 deposits of nickel-silicate ore occur in an area of 14 square miles north of São José do Tocantins, State of Goias. Conservative estimates of reserves indicate that the district as a whole may contain as much as 16 million tons of ore averaging between 1 and 3 percent nickel. About 1,400,000 tons of ore are available that have an average tenor of 4.5 percent nickel, with a possible yield from the district of as much as 5 million tons averaging 4 percent nickel. The American Smelting & Refining Co. had an interest in the Tocantins deposit, but abandoned it in 1944 chiefly because the pioneer conditions, due to geographical remoteness of the mine, the scarcity of labor, and the excessive cost of power, fuel, and freight were factors whose combined effect could not be successfully overcome. The deposits are accessible to the seacoast only by 200 miles of road south to Anapolis and thence 800 miles by rail to the port of Santos on the Atlantic Ocean.

Small deposits of nickel silicate ore are at Livramento and Ipanema in southern Minas Gerais. Each of the deposits contain a probable reserve of 200,000 tons and a possible reserve of 2 million tons averaging about 1.5 percent nickel. Some ore from the Livramento deposits has been used in an electric furnace to produce ferronickel.

VENEZUELA POSITION

Large deposits of nickel silicate ore have been found at Loma de Hierro. Some exploration has been done by the International Nickel Co. of Canada, Ltd. Data on ore reserves have not been published, but press notes have indicated that reserves exceed 30 million tons averaging about 1.75 percent nickel. The ore is reported to also contain a little cobalt and manganese and considerable iron and magnesium. The topographic situation of the ore-bearing blankets is very favorable for mechanized mining from open pits, from which the ore could be transferred to river site by aerial tramway.

NEW CALEDONIA POSITION

Excluding the U. S. S. R., New Caledonia is the only important nickel-ore producing country outside the Western Hemisphere. The largest ore-producing centers are at Thio on the east coast and Voh and Koné on the west coast. Production of nickel ore (containing about 25 percent moisture) was 392,050 metric tons in 1952 compared with 252,335 tons in 1951. The nickel content (dried) of the ore averaged 3.60 and 3.53 percent respectively, in 1952 and 1951. Most of the ore is converted to matte, fonte, and ferronickel in New Caledonia; the matte is exported to La Havre, France, for refining. In 1952, 97935 tons (wet) of ore averaging 3.41 percent nickel (dried) was exported to Japan and 11,905 tons averaging 5.6 percent nickel was shipped to France.

Figures on tonnage and grade of reserves of nickel ore in New Caledonia have not been published, but according to company figures the reserves are adequate to maintain an output of 12,000 metric tons of metallic nickel annually for 80 years.

SOURCES OF SUPPLY FOR UNITED STATES

In 1952 the United States obtained 87.2 percent of its supply of new nickel from Canada, 6.7 percent from Cuba, 5.4 percent from Norway, 0.6 percent from domestic production, and 0.1 percent from United Kingdom. The nickel received from Canada and Norway, and presumably that from United Kingdom, was produced from ore mined in the Sudbury disrtict of Ontario, whereas that received from Cuba was produced from ore mined in the Levisa Bay area in Oriente Province.

Nickel produced in and imported into the United States, 1948–52, in short tons of nickel

Year	Domestic production	Imports into United States				
		Canada	Cuba	Norway	Other countries	Total
1948	883	92,857	----------	3,110	73	96,040
1949	790	87,273	----------	3,782	18	91,073
1950	913	87,366	----------	3,604	311	91,281
1951	756	88,044	----------	4,780	292	93,116
1952	633	94,983	7,231	5,846	160	108,220

UNITED STATES TARIFF

Since 1922 there has been no duty on nickel ore and matte. Nickel oxide was dutiable at the rate of 1 cent a pound from 1922 to 1930 and has been duty-free since.

Under the Tariff Act of 1930 the United States import duty was 3 cents a pound on nickel metal. It was reduced to 2½ cents a pound as a result of the Canadian trade agreement in 1939 and was further reduced to 1¼ cents a pound by the Geneva agreement in 1948.

CONSUMPTION OF NICKEL

The United States is the largest consumer of nickel in the world. The largest foreign user of nickel is the United Kingdom, which consumed about 18,000 short tons in 1950, the latest year for which figures are available, compared with 98,900 tons in the United States. The combined consumption of nickel in the other free-world countries in 1950 was 54 percent less than in the United States.

Consumption of nickel in free-world countries in 1950

	Short tons, nickel content		*Short tons, nickel content*
Austria	1,340	Sweden	4,196
Canada	2,641	United Kingdom	18,062
France	4,469	United States	98,904
Germany	7,397	Other countries	4,200
Italy	1,486		
Japan	2,136	Total	144,831

Consumption of nickel in the United States, 1948–52

	Short tons, nickel content		*Short tons, nickel content*
1948	93,558	1951	86,416
1949	68,326	1952	101,048
1950	98,904		

SUBSTITUTES AND ALTERNATES

Many opportunities for adding to the availability of nickel for essential purposes are by tightening up on scrap salvage and by substitution. Nickel can be saved in relatively large amounts by the increased use of economy steels, such as triple alloy (nickel, chromium, molybdenum), boron-containing steels, and other substitute steels. There are also important opportunities for the downgrading of high nickel alloy compositions, where lower grade nonferrous alloys and stainless steels may often be substituted. Much of the nickel-containing stainless and heat-resisting steel production could be downgraded. Chromum-manganese alloys, some containing no nickel and some with minor additions of the element, are suitable alternates for specific applications of 18

percent chromium—8 percent nickel stainless steels. Nickel may be saved in nonvital uses of both soft and hard magnetic materials and to a limited extent by reducing its employment in aluminum-base piston alloys. The recent development of ductile iron in the United States foreshadows savings in nickel, since it can often be used alternately with alloy cast irons and steels. There are numerous applications of nickel and its alloys where the property requirements, especially corrosion resistance, concern only the surface of the product. Here, there is room for extension of the use of nickel and nickel-alloy-clad products.

FREE-WORLD PRODUCTION

Currently the free-world supply of nickel is being furnished chiefly by Canada, Cuba, and New Caledonia. The United States and Finland supply small quantities of nickel sulfate, which is recovered as a byproduct of copper refining; the Union of South Africa contributes a small quantity of nickel in the form of matte, which is produced from the complex ores in the Rustenburg district; and a little nickel is contained in the cobalt ore produced in French Morocco.

Free-world mine production of nickel, by countries, in 1951 and 1952

Country	1951		1952	
	Short tons of contained nickel	Percent of total	Short tons of contained nickel	Percent of total
Canada	137,903	93.55	140,007	85.74
Cuba (content of oxide)			8,958	5.49
Finland	94	.07	446	.27
French Morocco			201	.12
New Caledonia (content of ore)	7,400	5.02	11,600	7.10
Union of South Africa	1,254	.85	1,444	.89
United States	756	.51	633	.39
Total	147,407	100.00	163,289	100.00

ALLOCATION OF NICKEL

The free-world supply of primary nickel (excluding nickel salts) was allocated by the International Materials Conference from the fourth quarter 1951 through the third quarter 1953. In 1952 the United States was allocated 67.6 percent of the total supply.

Allocation of primary nickel (excluding nickel salts) to the free-world countries by the International Materials Conference in 1952

	Short tons
North America:	
Canada	4,249
Cuba	4
Mexico	18
United States	106,156
Total	110,427
South America	208
Total Western Hemisphere	110,635
Africa	93
Asia	1,691
Europe	43,900
Oceania	648
Total	156,967

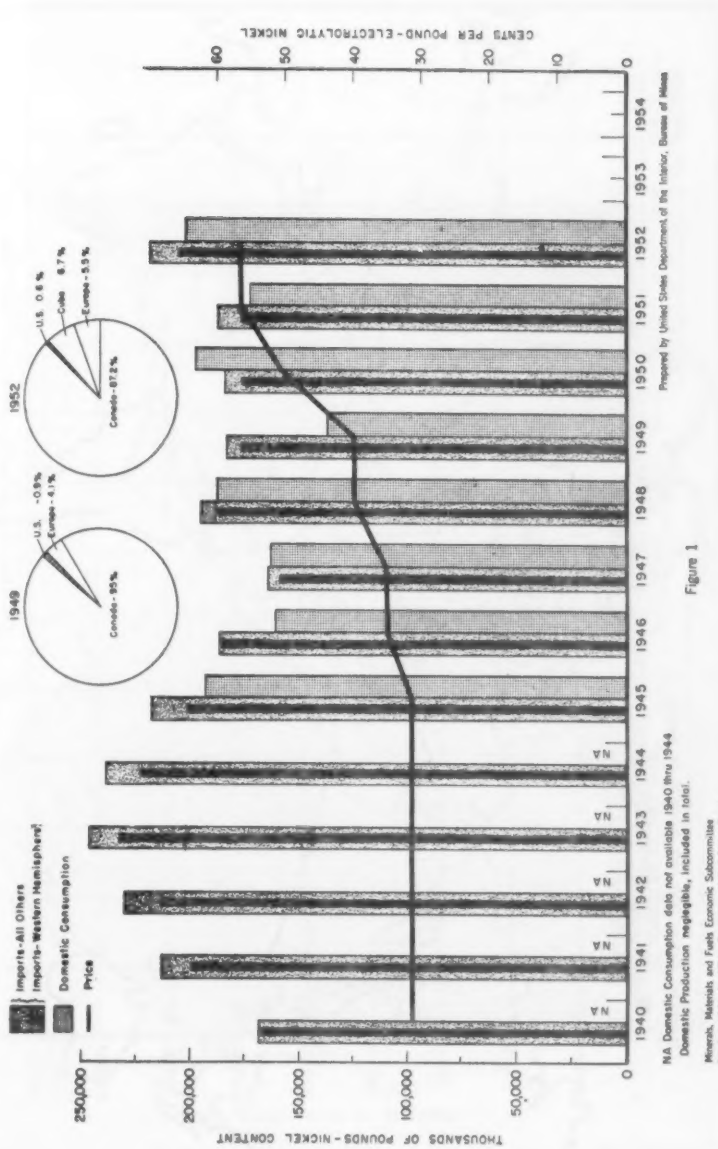
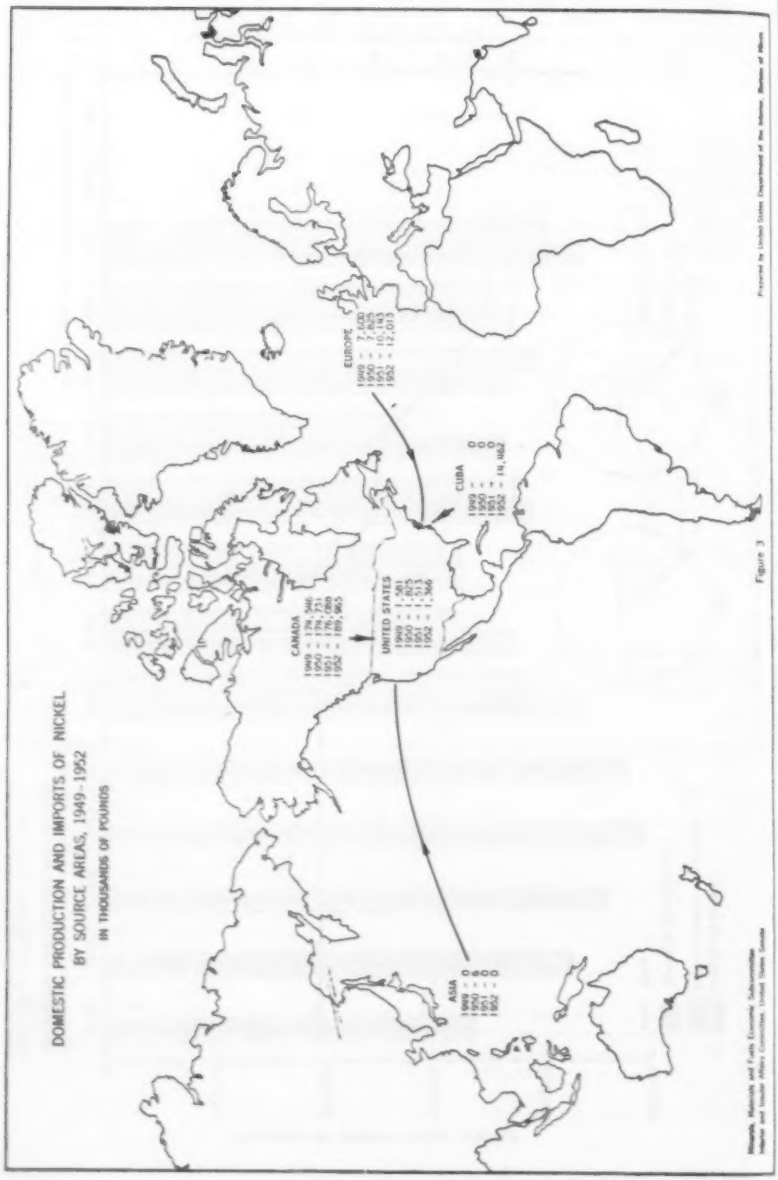
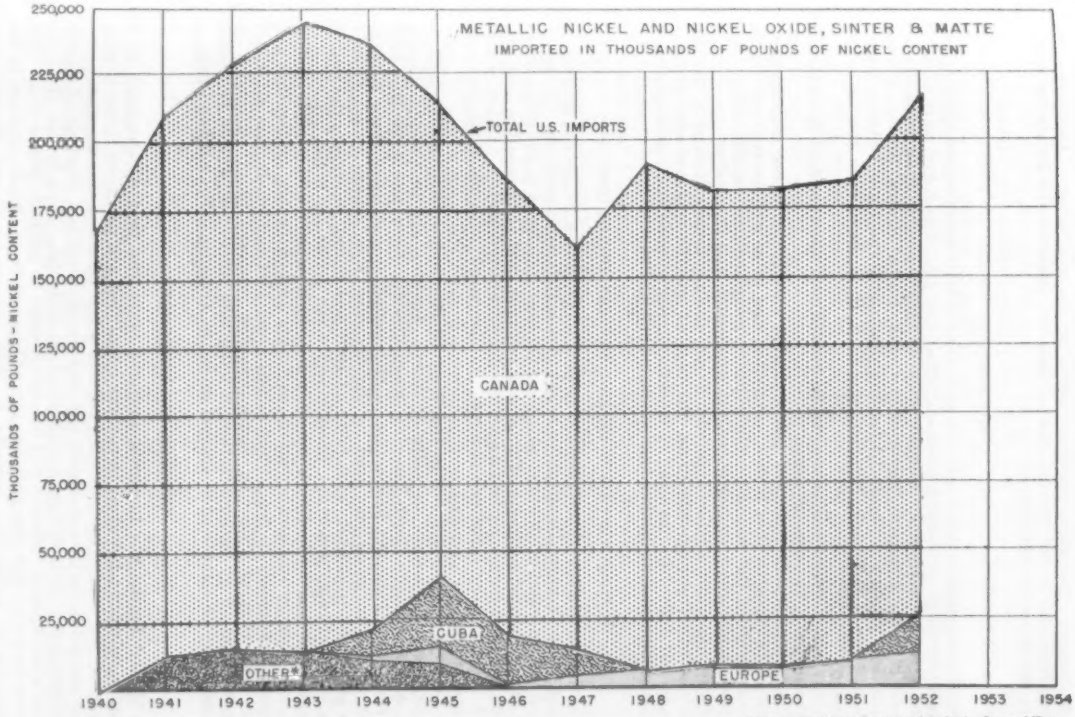

SUPPLIES AND CONSUMPTION OF NICKEL
YEAR END PRICES FOR ELECTROLYTIC NICKEL
Imports-All Others
Imports-Western Hemisphere
Domestic Consumption
Price
1949
U.S. - 0.9%
Europe - 4.1%
Canada - 95%
1952
U.S. 0.6%
Cuba 6.7%
Europe - 5.5%
Canada - 87.2%
THOUSANDS OF POUNDS - NICKEL CONTENT
250,000
200,000
150,000
100,000
50,000
0
CENTS PER POUND - ELECTROLYTIC NICKEL
80
60
40
30
20
0
1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954
NA
NA Domestic Consumption data not available 1940 thru 1944
Domestic Production negligible, included in total.
Prepared by United States Department of the Interior, Bureau of Mines
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 1


DOMESTIC PRODUCTION AND IMPORTS OF NICKEL
BY SOURCE AREAS, 1949-1952
IN THOUSANDS OF POUNDS
CANADA
1949 = 174,346
1950 = 178,730
1951 = 178,080
1952 = 189,965
UNITED STATES
1949 = 1,581
1950 = 1,825
1951 = 1,513
1952 = 1,566
EUROPE
1949 = 0
1950 = 7,630
1951 = 10,193
1952 = 12,013
CUBA
1949 = 0
1950 = 0
1951 = 0
1952 = 19,482
ASIA
1949 = 0
1950 = 0
1951 = 0
1952 = 0
Figure 3



*Includes 2,287,000 lbs. in 1943 and 665,000 lbs. in 1944 captured war material imported from French Morocco but originating in Canada.

Figure 2

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

TUNGSTEN

The wide fluctuations in demand for tungsten, with attendant swings in the price structure, create many problems for producers and consumers of the metal. Defense programs, including stockpiling, create productive capacity greater than that needed in more normal years, and many mines operate only during periods of peak demand. Technical problems regarding the utilization of low-grade ores are important, as is the development of new ore reserves for long-term operations in the Western Hemisphere.

SUMMARY

Tungsten is a metal much used in alloy steels for high-temperature applications, in tungsten carbide for cutting tools and armor-piercing shells, and as pure metal in lighting and electronics. Concentrates of tungsten-containing minerals are produced in many countries, historically China, United States, Burma, Bolivia, Portugal, and Korea have been the leading producers, and United States, United Kingdom, France, Germany, Sweden, and U. S. S. R. have been the important consumers.

In many instances molybdenum can be substituted for tungsten in steels but not in carbides or pure-metal uses.

The long-term trend for total use indicates greatly increased consumption; however, it is expected that both consumption and price will fluctuate violently, largely because of the unpredictable military component in requirements. The short-term demand is largely for defense production and stockpiling.

Problems important to the tungsten industry include uncertain supply, market, and prices, uncertain specifications, shortage of specific types of concentrates, and technical difficulties involved in working low-grade ore and concentrating it to a marketable product.

TUNGSTEN POSITION OF THE WESTERN HEMISPHERE

From the standpoint of ore reserves needed to support a long-term production of tungsten the Western Hemisphere is not in a satisfactory position. However, many of the potential producing areas have not been developed to the point which would permit a good estimate of total ore reserves, and it is possible that new ore will be found nearly as fast as known deposite are depleted. China is considered to have very large ore reserves, as compared with those of all other nations combined.

The reserves of tungsten ore in the Western Hemisphere are not confined to any one area. Important deposits of North America are in Canada, United States, and Mexico; in South America Brazil, Bolivia, Peru, and Argentina have large reserves. Tungsten production is distributed among these same nations.

Much of the tungsten produced in the Western Hemisphere comes from a rather small group of well developed and equipped mines; however, the output of small mines is also important, particularly when prices are high.

Recent developments in North America include expansion of ore reserves and productive capacity in Canada; plant expansion and extensive exploration and development programs in the United States; and Mexican production six times greater than that of 1950. In South America proposed plant expansion in Bolivia was halted by nationalization of important mines; expansion programs were underway or completed at several mines in Argentina, Brazil, and Peru.

STRATEGIC CONSIDERATIONS

The United States has imported tungsten since the first development of a consuming industry; however, important quantities are produced domestically, and in some recent months domesite production has exceeded consumption.

When potential wartime demands are considered, there is a shortage of supply after allowing for both domestic and imported material. As a result, the Government is stockpiling tungsten and has taken steps to increase production. One important factor in this regard is the loss of imports from China; another is the concentration of productive capacity in such nations as Korea, Bolivia, and Argentina, where war or political uncertainties may reduce our supply. It must also be recognized that estimates of requirements are conjectural and that during an actual war demands might be much higher or much lower than those now contemplated.

The outstanding factor with regard to the strategic situation is that, during defense periods, the demand for tungsten exceeds the normal rate of production.

No large increment of nonessential consumption can be drawn upon to supply defense needs. Government actions will afford an ample supply of the metal for requirements as now calculated, if there is no all-out emergency during the next few years, and they may provide a considerable surplus.

DEFENSE PROGRAM

Domestic production has been stimulated by a purchase program that provides a fixed price of $63 per unit for standard-grade concentrates up to July 1, 1958, or up to a total of 3 million units purchased, whichever occurs first. The Defense Minerals Exploration Administration program has assisted in the exploration of tungsten properties up to 75 percent of the cost of the work.

Foreign production has been increased by long-term Government purchase contracts and by loans. Also, the purchase of spot lots of tungsten concentrates has encouraged production at smaller mines.

UNITED STATES POSITION

The United States production of tungsten concentrates is now equivalent to 98 percent of consumption and the United States leads the free world in production. Output was stimulated by a domestic tungsten program of the Government which provided a firm price of $63 per short ton unit of tungsten trioxide in standard grade concentrates up to July 1, 1956, or until 3 million units were purchased. The expiration date was recently extended to July 1, 1958. Domestic production is still well below the potential emergency requirements, and tungsten concentrates are included in the group of materials being stockpiled. Production in the United States will increase in the near future, but not to the degree necessary to cover all-out requirements.

Production in 1952 was obtained from many widely scattered operations in 11 States and Alaska, but 4 States—California, Nevada, North Carolina, and Colorado—supplied 94 percent of the total; and 8 operators—Bradley Mining Co., Climax Molybdenum Co., Getchell Mine, Inc., Nevada-Massachusetts Co., Nevada Scheelite, Surcease Mining Co., Tungsten Mining Corp., and United States Vanadium Co.—produced 84 percent of the United States total. However, 1952 was marked by a very large increase in the number of mines producing tungsten ores, by a considerable increase in the quantity of tungsten produced by small mines, and by an increase in the number of mines producing material for shipment to custom mills.

The recent extension of the domestic tungsten program to July 1, 1958, will encourage further plant expansion, particularly at smaller mines. Large low-grade deposits in Montana have been explored, a new mine in Idaho has recently been opened, a large mill in Nevada has recently been completed, and many deposits have exploration projects in progress.

The most serious problem facing domestic producers is the eventual termination of the price-support program. The world price is now $40–$42 per short-ton unit (October 8, 1953); this price has declined from $51–$52 since the first of the year. The world price is supported, to some extent, by long-term contracts, most of which will terminate well before 1958. A sharp break in the price can certainly be expected. Much of the present domestic production is obtained from ores too low grade to work at pre-Korean-emergency prices.

The United States will continue to require imports of tungsten to cover requirements of an emergency period.

UNITED STATES RESERVES

Reserves of measured, indicated, and inferred tungsten ore in the United States are estimated to contain 160 million pounds of tungsten. Much remains to be learned regarding deposits of tungsten, and industry and Government investigations in progress will no doubt alter the reserve data. Many deposits have been worked to depths where exploration is more difficult and costly.

TARIFF AND PRICE

The Tariff Act of 1922 made tungsten ores and concentrates dutiable at 45 cents per pound of contained tungsten ($7.14 per short-ton unit—20 pounds WO_3) and provided compensatory rates of duty on ferrotungsten and other products. The act of 1930 increased the duty on tungsten contents of ore to 50 cents per pound

($7.93 per unit of WO_3), which was lowered to 38 cents per pound ($6.03 per unit of WO_3) in May 1948. In December 1950 import duties were restored to the 1930 levels.

Import duties on tungsten products	*Cents per pound of metallic tungsten*
Tungsten ore and concentrate: Tariff rate in—	
Act of 1930	50
1948	[1] 38
1951	[2] 50

[1] General agreement (Geneva). Rate effective May 22, 1948.
[2] Effective Dec. 11, 1950.

PROBLEMS

The sporadic nature of demand and price creates problems at the mines and mills:

1. Justification of large capital investments is difficult.
   (*a*) There is no incentive to develop several years' ore reserves.
   (*b*) Rapid writeoff of milling plants made necessary by market conditions leads to high milling charges. Many World War II mills were sold for junk before the recent increased demand for tungsten; as a result, some deposits have had three mills.
2. The grade of ore worked in periods of peak demand is very low; this introduces technical problems at mills and, to a smaller extent, at mines.

Problems that concern consumers of tungsten are:

1. Supply and price are uncertain.
2. The supply of the type of concentrates needed for a specific plant is also uncertain.
3. Trace-element impurities have important effects on end products, particularly at plants producing wire.
4. Government orders in defense periods are so large in relation to normal demands that sudden changes in the amounts of such orders create a need for corresponding changes in plant and labor force. This applies especially to the tungsten carbide projectile program.

Problems important to the Government are:

1. Providing for an assured supply of tungsten for defense needs.
   (*a*) From domestic sources.
   (*b*) From imports. This introduces the problem of a supply for other free-world countries.
   (*c*) From stockpile material.
2. Providing for an assured supply for future years.
3. Providing for industrial capacity to produce defense items.

A problem mutual to Government and industry is maintaining present United States technological leadership in mining, processing, and output of products. There is a trend toward establishing integrated plants in such countries as the Union of South Africa and Argentina. Export embargoes designed to encourage this trend must be anticipated. For example, Portugal now has a high export tax on tungsten concentrates and a lower tax on tungsten products. Unless domestic production of ore covers domestic needs, the United States may be forced to import products rather than raw material.

WORLD REVIEW

During the 44 years 1905–48 China, although it did not begin production until 1914, has supplied 28 percent of the world total and has been the premier tungsten-producing country. The United States has been the second-largest producing country, but has contributed only 13 percent of the world total. Burma has ranked third as a tungsten-producing country and has supplied nearly 13 percent of the world total. Thus China, the United States, and Burma have furnished nearly 54 percent of the world total. Bolivia, Portugal, and Korea, in the order named, have been the largest of the other producing countries and together have supplied 22 percent of the world total.

WORLD RESERVES

The world's largest reserves are in China. They are variously estimated at 1,300,000 to 4 million metric tons of 60-percent WO_3, equivalent to 1,360 to 4,200 million pounds of tungsten, or 7½ to 23 times the United States total. Reserves

in Burma, Thailand, Korea, Bolivia, Brazil, and Portugal are significant, although figures are lacking. New developments in Africa offer important possibilities.

WORLD TRADE

The United States is both a producer and a consumer of tungsten; Great Britain and France must depend largely, and Germany wholly, upon imports. When Government incentives are not in effect the United States depends upon foreign sources for one-third to one-half of its requirements. Great Britain is supplied chiefly by its colonies and by Burma, Portugal, Spain, Bolivia, and China. The concentrates from French Indochina are exported to France.

SOURCES IN THE WESTERN HEMISPHERE

Canada

In 1951 a very large, important ore body was discovered in Canada which will make a substantial contribution to United States imports. During 1953 the output is expected to exceed 2,500,000 pounds of tungsten, and it is estimated that by 1954 through 1958 the annual production will be 3 million pounds. The General Services Administration has contracted for a substantial part of this output. On the other hand, Canada will look to the United States for supplies of about 200 to 300 tons per year of ferrotungsten.

The most productive tungsten mine is the Emerald, in British Columbia. Production can probably be continued at prices somewhat lower than present markets. Other important mines include the Red Rose and Rocher de Boule, also in British Columbia.

Mexico

Mexico is an important producer of tungsten. The deposits are numerous and widely distributed but generally small or low grade. The recent revival of mining activity has been stimulated by long-term contracts granted by General Services Administration, but more could be done through exploration and development financing, technical assistance, construction of centralized custom mills, and relaxation of Mexican taxation. An appreciable drop in price will discourage many of the producers. Some tungsten concentrates produced in Mexico contain copper which must be removed by expensive chemical treatment.

Argentina

In 1950 the United States Government extended practical production incentives in the form of a substantial Export-Import Bank loan and a General Services Administration purchase contract to Sominar (Sociedad Minera Argentina, S. A.), the largest and only well-organized tungsten producer in the country. However, export regulations of the Government of Argentina prevented consummation of either agreement until March 1952. Argentine ability to meet the terms of the contract in the agreed period is questionable, even with the added contribution of producers other than those controlled by Sominar. The likelihood of ever again equaling the 1944 production level appears extremely remote. United States imports during the first half of 1953 were 453,000 pounds, tungsten content.

Bolivia

Bolivia is the leading tungsten producer in South America, ranks second to United States as a Western Hemisphere producer, and has been a major source of the tungsten imported to the United States. Some Bolivian tungsten concentrates are of the type and purity needed to produce tungsten wire for lamps and electronic devices.

The three leading producers of tungsten, Patino Mines & Enterprise Consolidated, Inc., Mauricio Hochschild (SAMI), and Cia Aramayo de Mines, in Bolivia, had negotiated loans totaling $2,580,000 to cover expansion of mine and plant facilities and purchase contracts with GSA. However, this expansion program was effectively halted when the mines were nationalized in October of 1952. The GSA also has contracts with the Bolivian Mining Bank and with International Mining Co. which were not affected by nationalization. Although the termination of the plant-expansion program will lead to a lower productive capacity in future years, recent shipments to the United States have been at a high level. During the first 6 months of 1953 1,301,000 pounds, tungsten content, were received.

Bolivian tungsten-ore reserves are estimated to contain 40 million pounds of tungsten metal; it is probable that a comprehensive exploration program would

reveal additional ore. Bolivia is one of the particularly important Western Hemisphere sources of tungsten when prices are low. Substantial quantities of tungsten are also recovered in refining Bolivian tin ores at the United States Government-owned tin refinery at Texas City, Tex. Some Bolivian tungsten is obtained as a byproduct of tin mining.

At the present time the political and economic situation in Bolivia is such that predictions regarding the future production of tungsten are very uncertain; the dependability of Bolivia as a major source of tungsten imports during an emergency will rest largely with these factors, rather than on technical problems at the mines.

Brazil

At present production of tungsten in Brazil is nearly equal to that of Bolivia; however, in 1949, when low prices prevailed, the production was about one-fifth of the Bolivian output. Some mines in Brazil have now been equipped with modern mine and mill plant and may be able to continue large-scale production of prices considerably lower than those now prevailing; additional mechanization will probably be required if the present high production is to be maintained.

Ore reserves are estimated to contain 40 million pounds of tungsten; however, there is considerable uncertainty regarding this estimate. Development of the scheelite deposits in northeastern Brazil may reveal much additional ore.

Brazilian capital shows little interest in mining, and the mining laws are often considered restrictive. However, Brazilian mining conditions, while not ideal, hold some attraction for foreign capital. Allowing for all factors, technical, economic, and political, Brazil should be a dependable source of future supplies of tungsten for the United States. During the first half of 1953 Brazil was the leading source of United States imports from areas in the Western Hemisphere.

Peru

In 1951 Peru produced 1.5 percent of the world output. The geology of the country is favorable, and there are many known occurrences; but lack of transportation and of small or centrally located concentrating mills to handle ores from surrounding feeder mines prevents present expansion. Peruvian mining law since May 1950 is probably the most favorable in the Western Hemisphere, with the possible exception of Canada, from the standpoint of offering a maximum of development incentives, and the resulting vigorous revival in mining activity has yet to reach its peak. As a continuing and expanding source of raw materials essential to the United States, Peru is one of the strongest countries in South America.

The Pasto Bueno mine was assisted to expand production by an Export-Import Bank loan. An important feature of the expansion program was an 80-kilometer road. Production in 1953 will probably be double that of 1952, and the increased production rate will be maintained for several years. In the first 6 months of 1953 the United States received 511,000 pounds, tungsten content, from Peru.

Africa

Africa has over 30 political divisions. The most important suppliers of tungsten have been the Belgian Congo and its mandate, Ruanda-Urundi, Union of South Africa and affiliate, South-West Africa, Uganda, and Southern Rhodesia, which in 1951 contributed 94 percent of total African production. Although these sources contain the great bulk of reserves in Africa, tungsten is also known to occur in French Cameroons and Egypt. Present production is not impressive, but good possibilities for expansion exist.

The Union of South Africa now uses or is about to use part of its production in manufacturing tungsten carbide, principally for consumption by its own large mining industry and that in other areas. Ultimately the Union's example may be followed by other producers, particularly the Belgian Congo and Uganda. Hydroelectric power for use in such manufacturing operations will be available by 1958 or earlier.

In the Union there is a growing tendency to advocate limitation of export production of tungsten and other critical minerals. This is proposed in part to further self-sufficiency, but it also results from a desire to save reserves until mine production can be processed locally and the profits represented kept at home. The output of concentrates over any required for local use or by the controlling country would be available to the United States on a world price basis. On the other hand, incentive to expand the industry would be mostly removed if the United States is eliminated as a market for African tungsten products.

All of the areas under discussion are in the southern half of Africa and consequently less vulnerable to enemy action than the Mediterranean littoral.

Portugal and Spain

The northwestern portion of the Iberian Peninsula is the world's fourth largest source of tungsten concentrates. A mineralized area extends across the international boundary and comprises the northern part of Portugal and the western part of Spain. Production during 1951 was 13.9 percent of the world total.

Taxes have an important effect on the production of tungsten concentrates. In Portugal the export tax is applied on the basis of tungstic oxide (WO_3 content), and under the decreased selling prices the Government is taking about 50 percent ad valorem. One large tungsten mine in Spain was assisted by an Export-Import Bank loan for mining machinery that is expected to increase production of concentrates as much as 500 metric tons annually. In Portugal five mines were assisted by European recovery plan financing, and an equal number will receive counterpart funds as soon as the projects are approved by the Portuguese Government.

Australasia

In recent years Australasia has mined about 5 percent of the world production of tungsten. The largest part has come from the open-pit mines of King Island Scheelite, Ltd., on King Island north of Tasmania. Production of tungsten is small and scattered in the rest of Australia. Mining in Australia is handicapped by poor transportation, great distances, low labor productivity, high wages, prohibitive taxation, and Government inertia. The bulk of Australian tungsten production has been exported to Europe, but the United States now receives a substantial quantity.

Burma

About half of the Burmese production has generally come from the British-owned Mawchi mine in remote Krenni, one of the southern Shan States. The peak output for Burma was approximately 8,300 tons of 60 percent WO_3 concentrates in 1941, 16.5 percent of the world's total for that year.

Thailand

Thailand normally supplies 2 to 3 percent of world output and ranks 10th among producing countries. It is important to the Western Hemisphere since the output of China is no longer available.

Peak production of 1,700 metric tons of 60-percent concentrates (WO_3) was reached in 1943 under Japanese occupation. This fell to 200 tons in 1946.

General conditions improved, and production (estimated) rose to 1,200 tons in 1950, despite Government restrictions and other uncertainties. 1952 production was estimated to be 1,600 tons.

The United States is likely to remain a leading importer in view of Reconstruction Finance Corporation loans and arrangements by the Wah Chang Trading Corp. (an American company) with leading producers. During the first half of 1953 the United States received 1,257,000 pounds, tungsten content, from Thailand.

China

China has the world's largest reserve of tungsten minerals. The grade of the deposits is much higher than those of other countries. Because the deposits have undergone only meager development, there is considerable difference of opinion regarding the reserves, but the total may be as much as 4 million metric tons of concentrates. Tungsten occupies second place in mineral production in China, in terms of value.

Overland transportation to the U. S. S. R. is difficult, but it is said that new railroads are under construction, which would relieve this difficulty. The important deposits are in Kiangsi and Kwangtung Provinces, some 200 miles in a direct line from the South China Sea and vulnerable from Formosa either for attack or occupation.

Korea

The Sang Dong mine and its surrounding area is one of the most important tungsten-producing regions in the world. The highest production was during the Japanese occupation in 1944, when 17 percent of the world total was produced. The mill at the Sang Dong mine was badly damaged during World War II when the Japanese were driven out; it has continued to be damaged during the present Koren war, until it is difficult to see how any production can be made, but it continues in operation at a good rate despite poor recovery.

Utah Construction Co. has recently obtained a contract with the Korean Government to rehabilitate the mine and mill. The General Services Administration

has a large contract with the Korean Government for the purchase of concentrates on a downward sliding scale for the next few years.

In 1952 and the first half of 1953 Korea was the greatest single source of United States imports of tungsten.

Consumption of tungsten in the United States, 1948–52

	Thousands of pounds, tungsten content		Thousands of pounds, tungsten content
1948	8,853	1951	11,410
1949	4,958	1952	8,634
1950	6,597		

Tungsten produced in and imported into the United States, 1948–52

[In pounds of tungsten content]

Year	Domestic production	Imports into United States							
		Canada	Mexico	Argentina	Bolivia	Brazil	Chile	Peru	Other countries	Total
1948	4,033,389	337,878	151,492	8,261	663,765	856,834	------	------	7,730,106	9,748,336
1949	2,896,084	------	84,239	------	1,044,982	64,496	------	31,074	6,132,508	7,357,299
1950	3,965,040	507	80,721	302,066	1,305,669	753,807	------	559,127	5,339,201	8,341,998
1951	5,913,750	------	231,897	17	948,169	1,070,213	533	431,198	4,850,838	7,532,865
1952	7,233,199	642,655	468,457	141,640	2,867,947	1,045,722	------	216,391	11,602,080	16,984,892

World production of tungsten ores, by countries, in metric tons of concentrates containing 60 percent WO_3, 1948–52 [1]

Country	1948	1949	1950	1951	1952
North America:					
Canada	791	191	215	15	923
Mexico	133	65	67	325	443
United States (shipments)	3,659	2,508	4,373	5,693	6,905
Total, North America	4,583	2,764	4,655	6,033	8,271
South America:					
Argentina	33	[2] 30	[2] 20	100	600
Bolivia (exports)	2,485	2,543	2,461	2,718	3,707
Brazil (exports)	1,144	575	759	1,422	[2] 1,800
Peru	353	455	516	655	630
Total, South America	4,015	[2] 3,600	[2] 3,760	4,895	[2] 6,700
Europe:					
Finland	4	49	20	8	47
France	567	792	442	765	[2] 1,000
Italy	4	3	2	6	5
Portugal	2,944	2,700	2,500	4,680	4,900
Spain	876	888	850	2,553	2,400
Sweden	317	468	362	[2] 450	[2] 380
U. S. S. R.[3]	5,000	6,000	7,500	7,500	(3)
United Kingdom	46	81	76	61	55
Total, Europe (estimate)	9,800	11,000	11,800	16,000	[4] 8,800
Asia:					
Burma	1,824	740	930	1,647	1,260
China	12,200	[2] 9,000	[2] 12,000	[2] 15,800	[2] 20,000
Hong Kong	------	------	------	23	104
India	------	------	2	15	------
Japan	9	20	64	86	239
Korea:					
Korea, Republic of	1,245	1,443	2,000	1,269	3,500
North Korea	1,000	1,000	[2] 1,000	[2] 1,200	[2] 1,200
Malaya, Federation of	87	69	27	54	79
Thailand [2]	800	1,100	1,200	1,350	1,600
Total, Asia (estimate)	17,200	13,400	17,000	21,400	28,000

See footnotes at end of table.

World production of tungsten ores, by countries, in metric tons of concentrates containing 60 percent WO_3, 1948–52 [1]—Continued

Country	1948	1949	1950	1951	1952
Africa:					
Algeria				17	75
Belgian Congo	236	276	164	330	[2] 500
Egypt	15			7	21
French Morocco	1		7	38	13
Nigeria	4	5	5	23	23
Southern Rhodesia	80	26	64	231	420
South-West Africa	13	6	4	33	118
Tanganyika (exports)	1	42	15	15	14
Uganda (exports)	115	180	218	167	109
Union of South Africa	151	416	96	188	263
Total, Africa	616	951	573	1,049	[2] 1,600
Oceania:					
Australia	1,234	1,371	1,235	1,892	[2] 2,000
New Zealand	28	28	24	35	[2] 35
Total, Oceania	1,262	1,399	1,259	1,927	[2] 2,035
Grand total (estimate)	37,500	33,100	39,000	51,300	[4] 55,400

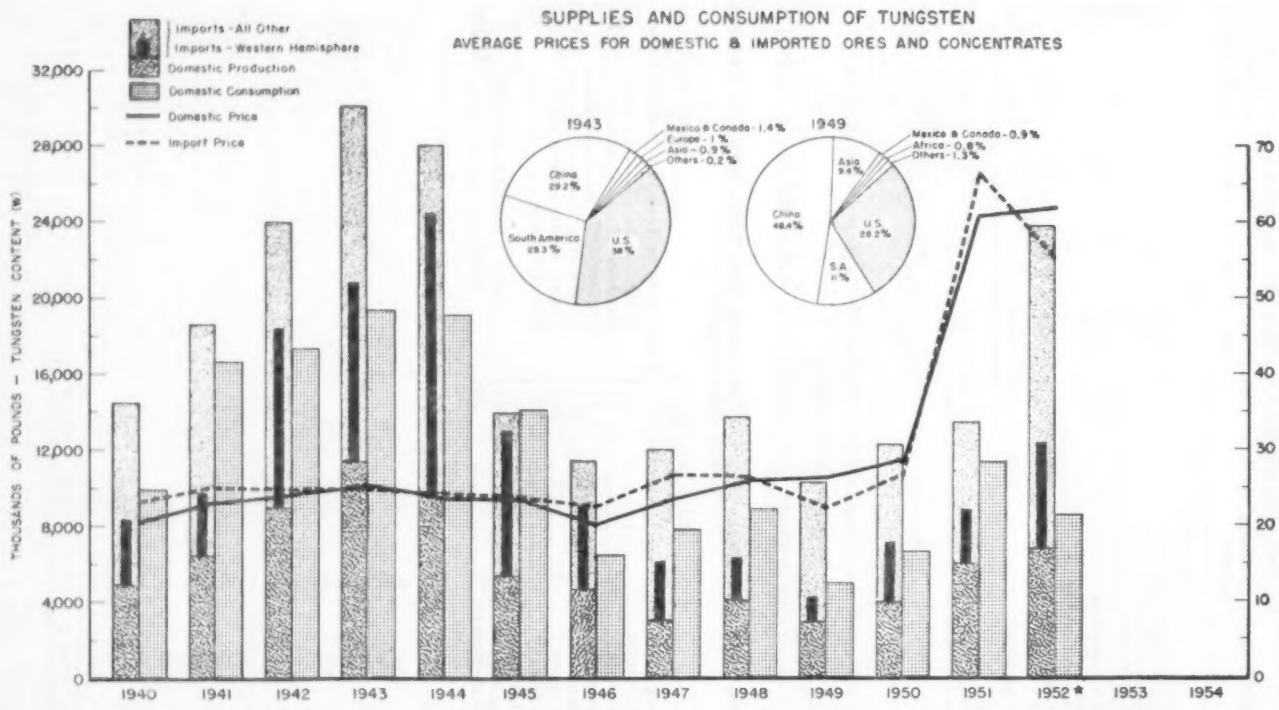
[1] This table incorporates a number of revisions of data published in previous tungsten chapters.
[2] Estimate.
[3] Data not available: No estimate included in totals.
[4] Excluding U. S. S. R.

Source: Foreign Minerals Statistics Unit, region IX, Bureau of Mines, June 18, 1953. Compiled by Pauline Roberts and Bernice B. Mitchell.

Summary of International Materials Conference distribution plans for tungsten concentrates, 1952

Country:	*Metric tons, tungsten content of concentrates*
Australia	78
Austria	31
Belgium	17
Canada	194
France	1,540
Germany	1,789
Italy	158
Japan	434
Netherlands	38

Country—Continued	*Metric tons, tungsten content of concentrates*
Spain	75
Sweden	756
Switzerland	30
United Kingdom	3,800
United States	8,865
Miscellaneous	41
Total production estimate	17,846

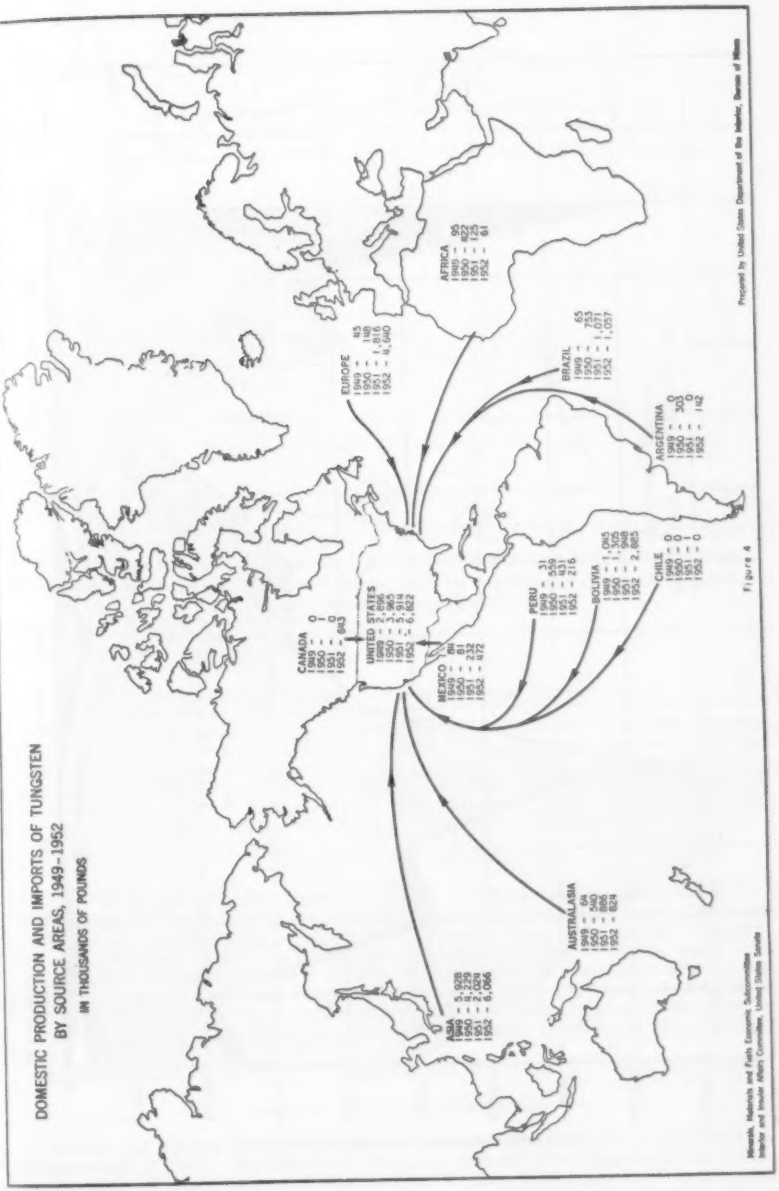


* Preliminary figures

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2

Prepared by United States Department of the Interior, Bureau of Mines


DOMESTIC PRODUCTION AND IMPORTS OF TUNGSTEN
BY SOURCE AREAS, 1949–1952
IN THOUSANDS OF POUNDS
CANADA
1949 = 0
1950 = 0
1951 = 0
1952 = 643
UNITED STATES
1949 = 2,985
1950 = 2,980
1951 = 5,914
1952 = 6,822
MEXICO
1949 = 891
1950 = 0
1951 = 232
1952 = 472
PERU
1949 = 31
1950 = 559
1951 = 931
1952 = 216
BOLIVIA
1949 = 1,045
1950 = 905
1951 = 948
1952 = 2,885
CHILE
1949 = 0
1950 = 0
1951 = 0
1952 = 0
ARGENTINA
1949 = 305
1950 = 0
1951 = 0
1952 = 142
BRAZIL
1949 = 65
1950 = 775
1951 = 1,075
1952 = 1,057
EUROPE
1949 = 85
1950 = 148
1951 = 1,810
1952 = 4,040
AFRICA
1949 = 95
1950 = 122
1951 = 70
1952 = 61
AUSTRALASIA
1949 = 64
1950 = 340
1951 = 386
1952 = 624
U.S.S.R.
1949 = 5,928
1950 = 5,229
1951 = 7,733
1952 = 6,066
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines
Figure 4

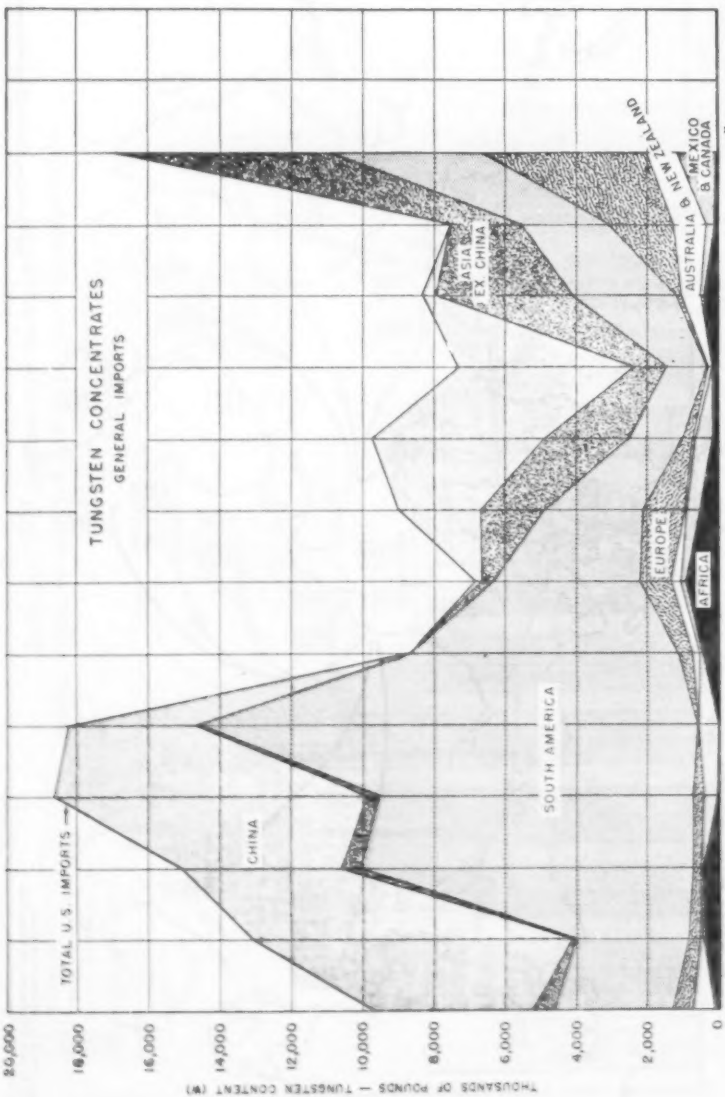

TUNGSTEN CONCENTRATES
GENERAL IMPORTS
TOTAL U.S. IMPORTS
CHINA
SOUTH AMERICA
ASIA EX CHINA
EUROPE
AFRICA
AUSTRALIA & NEW ZEALAND
MEXICO & CANADA
THOUSANDS OF POUNDS — TUNGSTEN CONTENT (W)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952*
1953
1954
* Preliminary figures
Prepared by United States Department of the Interior, Bureau of Mines
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 3

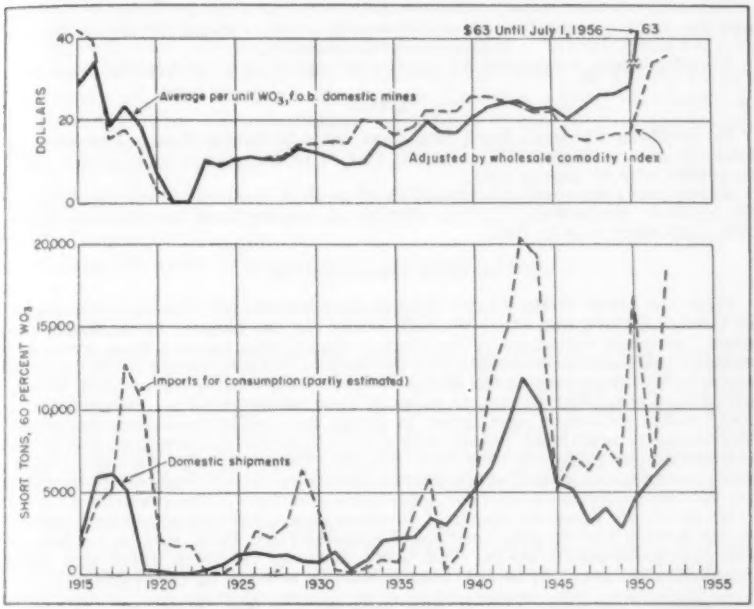


FIGURE 1.– Trends in domestic shipments, imports, and average price of tungsten ore and concentrates, 1915–52

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

THE VANADIUM POSITION OF THE WESTERN HEMISPHERE

Vanadium, although a strategic metal, is the least critical of all the alloying elements used for steel manufacture. Supplies of vanadium usually are ample to meet requirements of the United States, and it is only necessary to resort to substitutes and alternatives when, as in 1941–43, apparent tightness of vanadium was caused primarily by substitution of SAE steels, containing chromium and vanadium, for unobtainable nickel-containing steels.

UNITED STATES POSITION

The United States is the largest producer and consumer of vanadium in the world; but, for security reasons, publication of figures has been suspended since 1947 at the request of the Atomic Energy Commission. The Colorado Plateau, which comprises chiefly southwestern Colorado and southeastern Utah but extends into Arizona and New Mexico, is the center of vanadium-ore mining in the United States. Some vanadium is recovered as a byproduct of phosphate mined in Idaho. Vanadium is also recovered as a byproduct of chrome ore at Glens Falls, N. Y., and as a byproduct of petroleum residues at Wood-Ridge, N. J.

No information on reserves of vanadium ore in the United States is available.

WESTERN HEMISPHERE POSITION

Outside the United States, the chief producer of vanadium ore in the Western Hemisphere is Peru. Production is from the famous Mina Ragra of the Vanadium Corp. of America in the Andes near Ricran, Department of Junin, and it has been an important source of vanadium since 1907. Output was 804 metric tons of V_2O_5 in 1952 compared with 801 tons of V_2O_5 in 1951. The entire output is exported to the United States.

Vanadium occurs in small deposits widely scattered in the Provinces of Cordoba and San Luis in Argentina. A small quantity of ore is mined for the production of 3 to 7 metric tons of vanadium pentoxide annually.

No information is available on reserves of vanadium ore in Peru or Argentina.

AFRICA

In Northern Rhodesia fused vanadium oxide is produced as a byproduct of lead-zinc ores at Broken Hill. Output was 43 metric tons of vanadium in 1952 compared with 87 tons in 1951.

Vanadium is recovered as a byproduct of the lead vanadates of the Otavi region in northern South-West Africa. Output of concentrates (recoverable V_2O_5) was 1,228 short tons in 1952.

OUTLOOK FOR PRODUCTION

Since the entry of the Atomic Energy Commission into the carnotite region of Colorado, Utah, and other Western States for the purpose of obtaining uranium, output of vanadium in the United States, plus imports from Peru, has exceeded industry requirements, and the surplus has been placed in the national stockpiles. The nature of the domestic ore is such that vanadium will be produced as a coproduct in greater quantity than uranium. Also, the program of AEC makes economic, ores lower in grade than could previously be mined. Furthermore, additional plants primarily for producing uranium are under construction or projected. For these reasons, the potential production of vanadium from the Colorado Plateau, plus imports from Peru, is expected to be ample for defense requirements and for appreciable additions to the stockpile.

However, the potential output of vandium as a coproduct of uranium mining in the United States, plus anticipated supplies from Peru, will be inadequate for full mobilization needs; and other sources, of which there are large reserves, will have to be brought into production to make up the deficiency.

Senator MALONE. Thank you very much, Mr. Melcher. We will now recess until 1 o'clock.

(Thereupon at 12:10 p. m., a recess was taken until 1 p. m.)

AFTERNOON SESSION

(The hearing was resumed at 1 p. m., same day.)

Senator MALONE. The committee will be in order.

STATEMENT OF CHARLES H. JOHNSON, CHIEF OF THE BASE METALS BRANCH, BUREAU OF MINES

Mr. JOHNSON. Charles H. Johnson, Chief of the Base Metals Branch, Bureau of Mines.

Senator MALONE. What commodities are covered by the Base Metals Branch?

Mr. JOHNSON. That deals with nine commodities:

Antimony, arsenic, bismuth, cadmium, copper, lead, mercury, tin, and zinc.

Senator MALONE. Mr. Johnson, you are generally familiar with the work of the Committee on Minerals, Materials, and Fuels, as you have already prepared considerable data for the committee.

Mr. JOHNSON. Yes, sir.

Senator MALONE. Would you go ahead with your general statement in the order of minerals?

ARSENIC

Mr. JOHNSON. I have not prepared any statement on arsenic, because I believe it is not one of those commodities in which the commit-

tee is interested. It is a commodity that is in ample supply, and has no strategic problems. It is, however, included on the chart which you have there. You will find it in the top row.

Senator MALONE. Chart No. 2, already submitted as a part of the testimony of Mr. Zinner. Arsenic is included under the first list produced in the United States, of which there is a virtual self-sufficiency assured for a long time under the heading.

Mr. JOHNSON. Yes, sir.

Senator MALONE. And that is your best judgment, that in the foreseeable future we have ample arsenic?

Mr. JOHNSON. Yes, sir.

Senator MALONE. Proceed with the next mineral.

ANTIMONY

Mr. JOHNSON. Antimony has been consumed in the United States in the past 5 years at the rate of about 39,000 tons a year. The average price during that period was 40 cents a pound, so this quantity of antimony can be valued at about $31 million a year.

Of this metal, about 57 percent was of secondary origin. This was derived mostly from old automobile storage batteries being turned back in.

Senator MALONE. It is reclaimed metal?

Mr. JOHNSON. Yes, sir. The supply of primary antimony, about 19,000 tons yearly, was obtained largely from abroad. Almost three-quarters of the primary supply was imported, chiefly in the form of antimony ores, and concentrates, to be smelted domestically. About a sixth of the primary supply was obtained from domestic antimony mines. A small quantity was a byproduct of lead and zinc ores, which came both from this country and abroad.

Mexico and Bolivia each supplied roughly a third of our imports during that 5-year period. Mexico furnishes both metal and concentrate. Bolivia ships concentrate. Peru and Chile contributed a few hundred tons each year, and a little bit from countries outside of the Western Hemisphere.

The Western Hemisphere production of primary antimony in that same period, from 1948 through 1952, was about 23,500 tons a year, so you will see that this is in excess of Western Hemisphere needs. We do not know accurately the consumption of all Western Hemisphere countries, but taking the United States and Canada as the major consumers it appears that Western Hemisphere production is in excess of its average consumption.

Senator MALONE. You are speaking, of course, particularly of the United States, that it has had or would have no difficulty in importing the amount necessary for our domestic consumption from the Western Hemisphere?

Mr. JOHNSON. That is correct, sir.

Senator MALONE. Do you know the consumption in each one of the other nations of the Western Hemisphere, or are you just assuming that they provide for their own needs and then contribute to our needs to the extent shown on the map and by your testimony?

Mr. JOHNSON. That is the assumption; yes, sir.

Senator MALONE. Go ahead.

Mr. JOHNSON. The largest reserves of antimony in the United States are in Valley County, Idaho. Although the antimony content of

these deposits is low by some standards, they can be mined cheaply. They also contain tungsten and gold, which add to the value of the ore.

Many other antimony deposits have been mined in Western States, chiefly in Nevada and California. These for the most part are straight antimony ores, with less byproduct value. They are typically small and lenticular, spotty, with a relatively high mining cost, and can be operated profitably only when the price is unusually high.

Senator MALONE. Would you please describe for the benefit of the record what you would call unusually high? In other words, are not all of these expressions relative expressions?

Mr. JOHNSON. They are certainly relative.

Senator MALONE. The reason you have tall men is because you have short men.

Mr. JOHNSON. Yes, sir. I meant relatively high, with reference to past experience.

Senator MALONE. Would you give us the price necessary for these domestic ores to come into production?

Mr. JOHNSON. I do not know that I can do that.

Senator MALONE. Some general idea of conditions which might be required for the Idaho stibnite area to resume production.

Mr. JOHNSON. The production in Idaho ceased when the price fell a year or two ago from 50 cents to around 30 cents.

Senator MALONE. Fifty cents per pound to thirty cents?

Mr. JOHNSON. It dropped as low as 26 cents, I believe. It is now standing at around 36 cents. You might conclude that is not a sufficient price, as things are now, to permit profitable operation.

Senator MALONE. From past experience what price would you judge would start the mines in operation? Forty cents, forty-five cents, or what price?

Mr. JOHNSON. I think it would be hazardous for me to say that. I think an assured price, such as we had before at the 50-cent level, ought to do it.

Senator MALONE. If they had a principle established under which the ore would normally sell for somewhere around 45 to 50 cents, or above, our domestic mines, many of them, would go into operation, you believe?

Mr. JOHNSON. I think so.

Senator MALONE. It is a long-range principle.

Mr. JOHNSON. Yes, sir.

Senator MALONE. You said our annual consumption was about how many tons?

Mr. JOHNSON. The primary and secondary together was about 39,000 tons, with 19,000 tons of primary.

Senator MALONE. And the secondary, of course, is reclaimed metal?

Mr. JOHNSON. Yes, sir.

Senator MALONE. Of course, the price might have something to do with the recovery of secondary metal, might it not?

Mr. JOHNSON. I believe the secondary metal is quite well used as it stands now.

Senator MALONE. Even at 36 cents the secondary metal might be available?

Mr. JOHNSON. It is recovered in the form of antimonial lead.

Senator MALONE. Do you think the reclaimed secondary metal amount would be increased if the price were around 50 cents?

Mr. JOHNSON. Not greatly.

Senator MALONE. But the primary metal would. What is the purity of the 19,000 tons of primary metal?

Mr. JOHNSON. That is in various forms. Some is metal and some is oxide.

Senator MALONE. Off the record.

(Discussion off the record.)

Senator MALONE. The committee will stand in recess until 9:30 tomorrow morning.

(Whereupon, at 4:20 p. m., the committee recessed, to reconvene at 9:30 a. m., Thursday, October 22, 1953.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

FRIDAY, OCTOBER 23, 1953

UNITED STATES SENATE,
SUBCOMMITTEE ON MINERALS, MATERIALS,
AND FUEL ECONOMICS, OF THE COMMITTEE
ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to recess, at 9:30 a. m., in the committee room, 224 Senate Office Building, Washington, D. C., Senator George W. Malone, Nevada, chairman of the subcommittee, presiding.

Present: Senator George W. Malone, Nevada (chairman of the subcommittee).

Present also: Jerome S. Adlerman, counsel to the subcommittee; George B. Holderer, committee engineer.

Senator MALONE. The committee will be in order.

Mr. Johnson, you were testifying the day before yesterday when it was necessary to revert to other testimony on account of accommodating out of town witnesses. Would you just proceed as if you had not been interrupted, if that is possible.

STATEMENT OF C. H. JOHNSON, CHIEF, BASE METALS, BUREAU OF MINES, DEPARTMENT OF THE INTERIOR—Resumed

Mr. JOHNSON. I had said all I wished to on the subject of antimony. If you do not have further questions on that, Senator, I would like to submit a statement for the committee's use.

Senator MALONE. This is really a text on antimony production and availability?

Mr. JOHNSON. Yes, sir.

Senator MALONE. Do you cover possible substitutes in this text?

Mr. JOHNSON. Where it has seemed that would be an important element of the commodity situation, I have tried to do that.

Senator MALONE. Have you also covered in the text our record of production in this country over a period of years and the imports from the Western Hemisphere and from offshore nations?

Mr. JOHNSON. Yes, we have. It may not be a long enough record for your purposes, and if it is not, we would be very glad to add to it.

Senator MALONE. Mr. Johnson, your organization, the Bureau of Mines in the Department of Interior, prepared three charts on antimony, no doubt under your direction.

Mr. JOHNSON. The figures were furnished by us.

Senator MALONE. And also the charts were prepared under your direction. They are listed as prepared by the United States Department of Interior, Bureau of Mines, with a note "Minerals, Materials, and Fuels Subcommittee, Interior and Insular Affairs Committee of the United States Senate." In other words, they are prepared for this committee.

Mr. JOHNSON. Yes, sir.

Senator MALONE. Would you care to submit those charts for the record?

Mr. JOHNSON. That is certainly a worthwhile addition to the text statement, and I believe there are similar charts related to each of the commodities of which I will speak.

Senator MALONE. I believe so. They have been under preparation for several months, because they are a very important contribution to the factual material being collected by the committee upon which our conclusions must be based. They will be a large factor in aiding the committee to formulate logical conclusions.

No. 1 chart shows the domestic production from 1948 to 1952, inclusive, the imports from the nations of the Western Hemisphere, and other imports from other foreign nations and offshore areas.

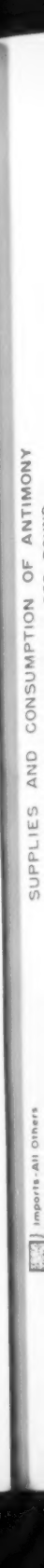
It is a bar chart showing also for the same period the annual consumption. They also have through a circle graph a showing of the division of the production, listing Mexico as 30 percent in 1947—these are our imports—Bolivia 10 percent, the Asian nations lumped together, 30 percent, Chile 25 percent, United States 25 percent. The same division, sources of material used, imported into the United States, 1952, shows United States production 13 percent, a notable decrease, as was testified here yesterday by one of the principal producers, Bolivia, 33 percent; Mexico, 20 percent, and Europe 27 percent.

Chart No. 2 shows over the same period 1940–52 in thousands of short tons, the source of these materials graphically from North America, South America, and other nations.

The third chart shows domestic production and imports of antimony by source areas 1949–52 for every nation in the world which was the source of such imports through those years, and the United States production.

These charts will be attached to text and submitted to be included in the report at this point as a part of your testimony, Mr. Johnson.

(The charts referred to are as follows:)



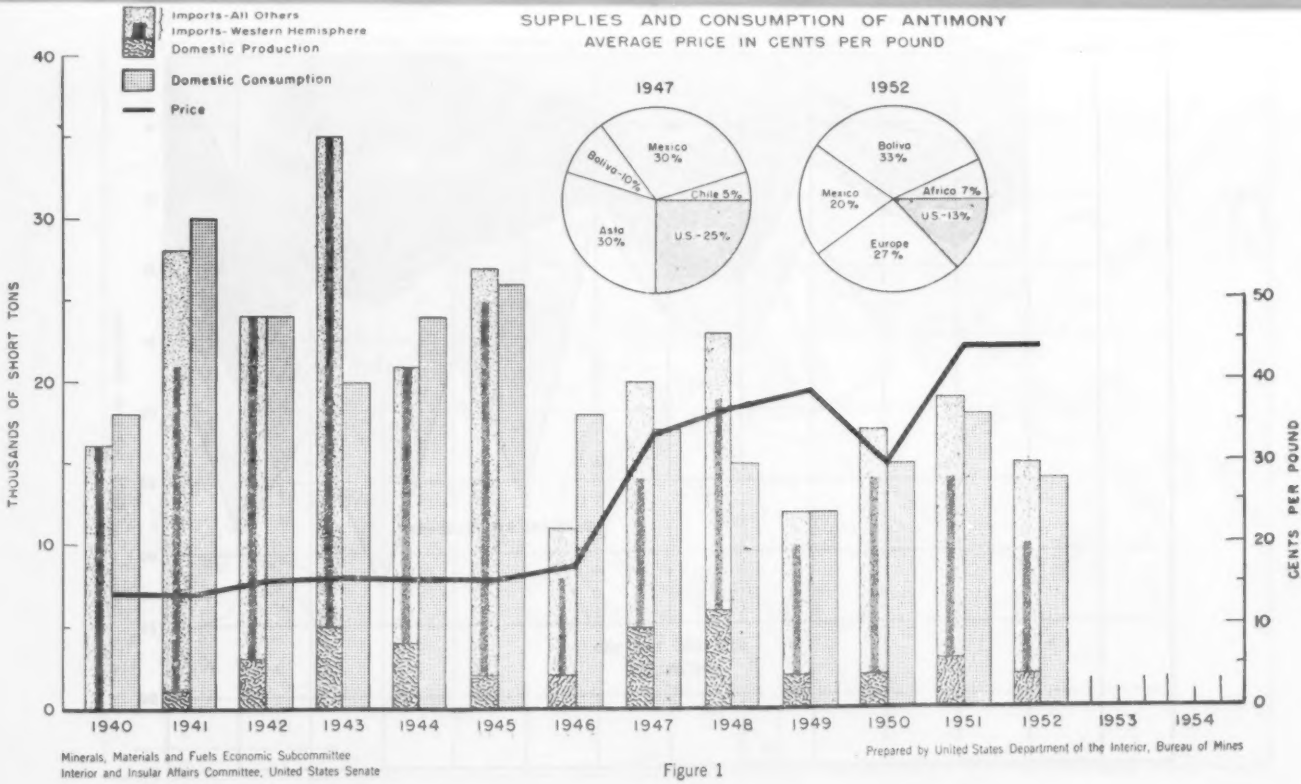

SUPPLIES AND CONSUMPTION OF ANTIMONY
AVERAGE PRICE IN CENTS PER POUND
Imports-All Others
Imports-Western Hemisphere
Domestic Production
Domestic Consumption
Price
1947
Mexico 30%
Bolivia 10%
Chile 5%
Asia 30%
U.S. 25%
1952
Bolivia 33%
Mexico 20%
Africa 7%
U.S. 13%
Europe 27%
THOUSANDS OF SHORT TONS
CENTS PER POUND
0
10
20
30
40
50
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

Figure 1

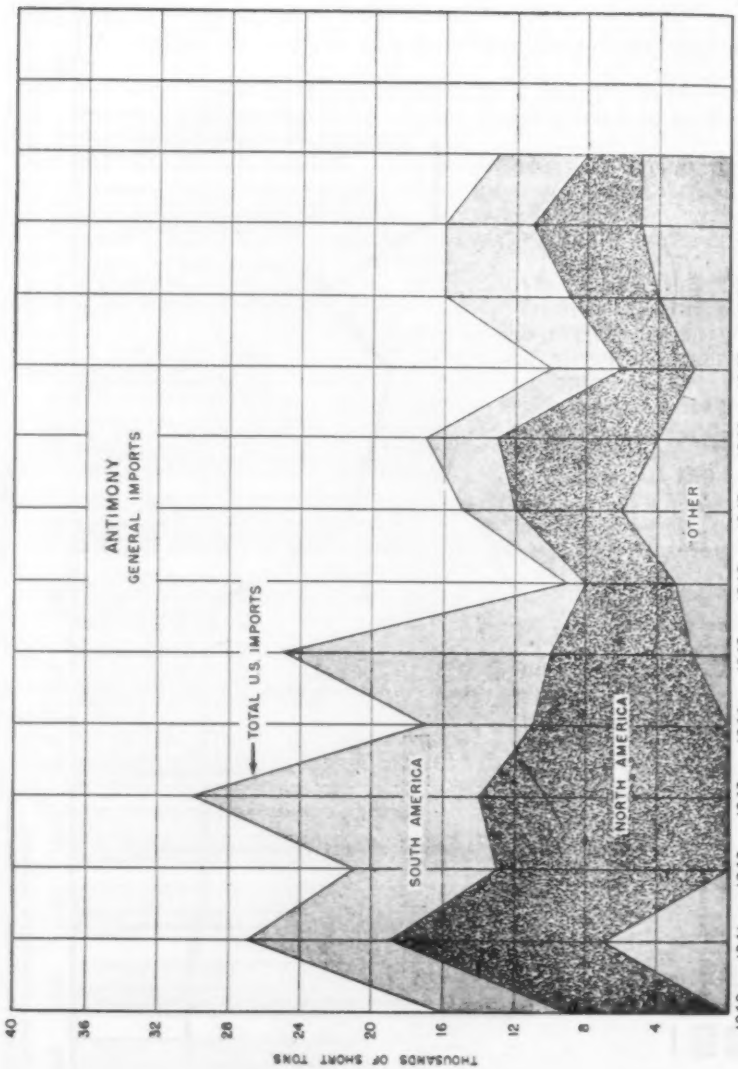

ANTIMONY
GENERAL IMPORTS
TOTAL U.S. IMPORTS
SOUTH AMERICA
NORTH AMERICA
OTHER
THOUSANDS OF SHORT TONS
40
36
32
28
24
20
16
12
8
4
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
Prepared by United States Department of the Interior, Bureau of Mines
Minerals, Materials, and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

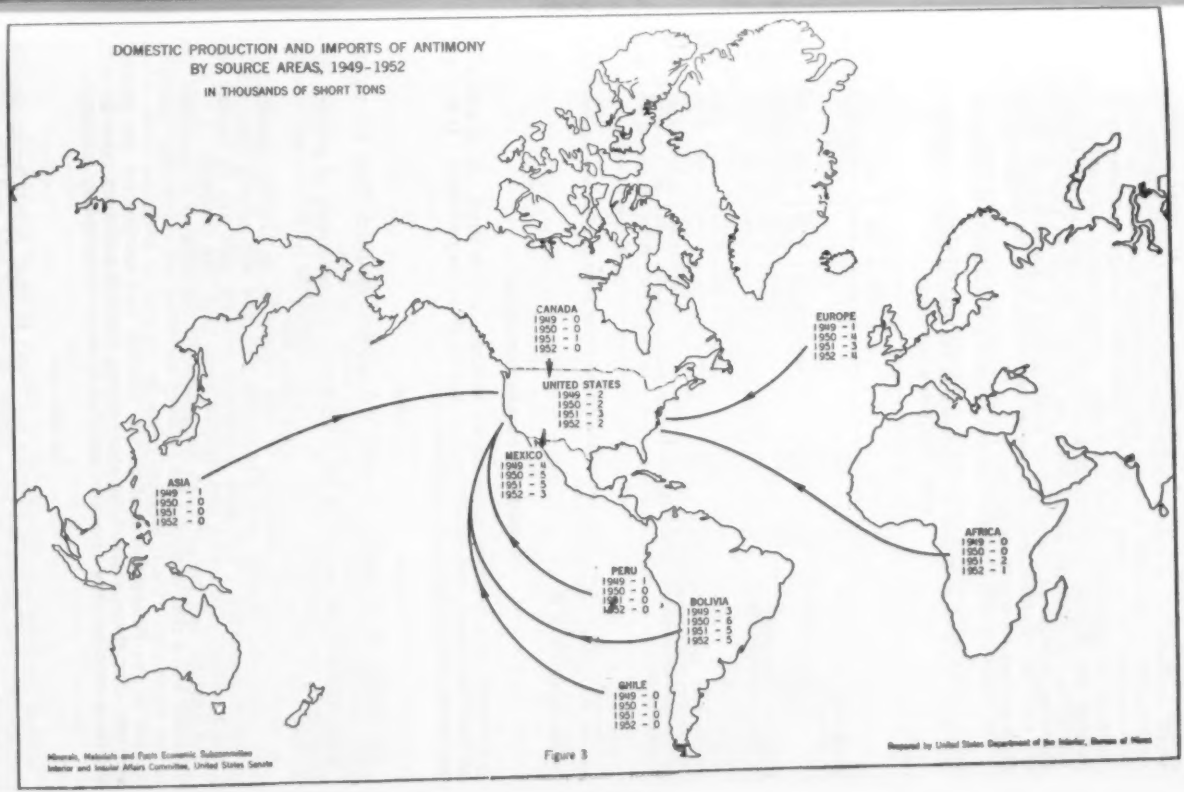
Figure 2

1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2

Prepared by United States Department of the Interior, Bureau of Mines



Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 3

Prepared by United States Department of the Interior, Bureau of Mines

ANTIMONY

The United States requires more antimony than all other countries of the world combined yet is almost wholly dependent upon foreign supplies. Intensive examination of domestic reserves and occurrences has failed to bring to light deposits that can compete in normal times with foreign antimony derived from richer or more cheaply mined ore bodies. Mexico has a substantial exportable surplus, and Bolivia, once a leading producer, is believed to have large reserves, therefore, the Western Hemisphere as a whole is more nearly self-sufficient. However, because of the ability of South Africa to produce large quantities at low cost, the establishment of a prosperous industry in the Western Hemisphere faces serious economic obstacles.

The following table presents salient statistics of antimony for 1948–52:

TABLE 1.—*Salient statistics of antimony in the United States, 1948–52, in short tons (antimony content)*

	1948	1949	1950	1951	1952
Production:					
Primary:					
Mine (shipments)	6,500	1,600	2,500	3,500	2,200
Smelter	14,300	8,100	9,500	12,200	11,900
Secondary	21,600	18,100	21,900	23,900	23,100
Imports for consumption	17,000	9,400	15,400	15,700	12,800
Ore and concentrates	13,500	7,500	9,700	11,800	7,900
Sulfide	370	60	13	4	24
Metal	3,200	1,900	4,600	2,200	3,400
Oxide	.....	50	1,000	1,700	1,500
Exports of ore [1] and metal and alloys	330	500	150	170	160
Consumption of primary antimony [2]	15,500	11,300	15,200	17,400	14,300
Average price of antimony at New York,[3] cents per pound	36.67	38.73	29.41	44.17	44.02
World production [4]	49,600	40,800	48,500	68,300	50,700

[1] Gross weight.
[2] Does not include antimony contained in domestic and foreign silver and lead ores, recovered at lead refineries and marketed in antimonial lead.
[3] American Metal Market.
[4] Exclusive of U. S. S. R.

DESCRIPTION AND PROPERTIES

Antimony is a lustrous white metal, having a bluish tinge. It is somewhat harder than copper, and so brittle that it can readily be powdered. It is a poor conductor, both of heat and electricity.

USES

On account of its unique chemical and physical qualities, there are no adequate substitutes for antimony in its most important uses.

Approximately 60 percent of the United States consumption of primary antimony is in the nonmetalic form—in the flameproofing of paints, plastics, and textiles, and also in ceramics, pigments, glass, etc.

In metallic products, antimony is used mainly as an alloying element with lead. Antimony hardens and strengthens lead and also greatly improves its corrosion resistance. The most important metallic uses are in storage batteries, bearings, type metal, and miscellaneous hard lead products.

The wartime uses for antimony are practically the same as in peacetime, the difference being that demands for primary antimony are enormously increased during waretime. This is especially true in the case of antimony oxide, which is used in the flameproofing of paints, plastics, and textiles for the military services. For these nonmetallic applications, primary antimony must be used, and these requirements cannot be satisfied by scrap or secondary antimony.

OCCURRENCE

Several antimony-bearing minerals are found in many metalliferous deposits that are exploited largely for lead, copper, silver, and gold, and this antimony is finally recovered in the ordinary processes of smelting and treatment. Deposits that contain only stibnite (antimony sulfide), the principal source of antimony, are uncommon. In such occurrences the ore is commonly in narrow lenticular veins and, even though these persist downward in the earth, experi-

ence in mining shows that the shoots of antimony sulfide are sporadic and largely confined to shallow surficial zones. For these reasons, the appraisals of reserves of antimony minerals are highly speculative unless the deposits are thoroughly explored.

WORLD PRODUCTION

The estimated world production of 51,000 short tons of antimony in 1952 was about 18,000 tons less than in 1951 and increased 28 percent over the 1943–47 average (39,700 tons). Of the total output, North America supplied 19 percent; South America, 23 percent; Europe, 16 percent; Asia, 21 percent; and Africa, 21 percent.

Table 2 presents world production in short tons, by continents, from 1948–52.

TABLE 2.—*World production of antimony (content of ore), 1948–25, in short tons* [1]

	1948	1949	1950	1951	1952
Western Hemisphere:					
Argentina [2]	100	100	------	100	100
Bolivia	13,500	11,300	9,700	13,000	10,800
Canada	200	100	300	700	1,300
Mexico	8,100	6,300	6,500	7,500	6,100
Peru	1,700	800	1,000	1,200	600
United States	6,500	1,600	2,500	3,500	2,200
Total	30,100	20,200	20,000	26,000	21,100
Europe [2]	8,500	7,300	8,000	8,200	8,200
Asia	4,600	5,700	8,600	13,300	10,800
Africa	6,200	7,400	11,700	20,500	10,400
Oceania	200	200	200	300	200
World total	49,600	40,800	48,500	68,300	50,700

[1] Does not include antimonial lead ores.
[2] Estimated.
[3] Excludes U. S. S. R.

Mexico has been the dominant source of antimony in North America for many years. Although China and Bolivia have usually exceeded Mexico, their outputs have been erratic and subject to many uncertainties. Mexico's production has also varied greatly, but the extent of the variations have not been as pronounced because of its favored position in the United States market. This position is due largely to proximity to the United States and to the fact that the ores are transported by rail to the Laredo, Tex., smelter and do not depend upon long and, at times, uncertain transport by ocean.

More antimony was produced in Bolivia during the Second World War than in any other country. The annual output of Bolivian ore from 1939 to 1952, inclusive, averaged more than 10,000 tons of contained antimony, most of which was shipped to the United States. The greater part of the ore was produced from small workings by native operators. Inferred reserves are large and are believed sufficient for some decades at the current rate of production. Bolivia is capable of expanded output if stimulated by moderately high prices.

Large reserves of high-grade antimony ore recently have placed the Union of South Africa in the fore as one of the world's leading antimony producers. In 1952 the Consolidated Murchison Mines, in the Union of South Africa, produced 8,000 short tons of antimony, representing 16 percent of the world production. Minor supplies come from Belgium-Luxembourg, Canada, Greece, and Yugoslavia.

DOMESTIC PRODUCTION

In the United States numerous antimony deposits have been explored, but the principal sources are a few districts in Idaho, Nevada, California, and Alaska. Other occurrences have been explored in Arkansas, Arizona, Montana, New Mexico, Washington, and Oregon, but the production has been small and intermittent. At high prices, some deposits in the interior of Alaska could become important sources of antimony.

The principal domestic producer was the Yellow Pine mine and smelter at Stibnite, Idaho, operated by the Bradley Mining Co. Before shutting down in the summer of 1952, this property had supplied about 90 percent of the domestic primary antimony output in recent years. The productive capacity of the prop-

erty is equivalent to about 20 percent of the total United States peacetime needs or about 10 percent of the wartime requirements for primary antimony. Although the mine has not resumed production, exploration work (financed to the extent of 75 percent by the Defense Minerals Exploration Administration) is being continued. The Yellow Pine mine contains about one-half of the known domestic antimony-ore reserves and the present indications are that the exploration program will result in increasing these reserves.

The following table presents the mine production (shipments), imports, exports, and apparent consumption of primary antimony in the United States, 1948–52, in short tons:

TABLE 3.—*Production (shipments), imports, exports and apparent consumption of primary antimony in the United States, 1948–52, in short tons*

Year	Production	Imports	Exports	Apparent consumption
1948	6,489	17,038	327	23,200
1949	1,636	9,429	485	10,580
1950	2,497	15,358	154	17,701
1951	3,472	15,673	168	18,977
1952	2,160	12,789	161	14,788
5-year average	3,251	14,057	259	17,049

The following table presents antimony content in antimonial lead from domestic ores and secondary antimony produced in the United States, 1948–52, in short tons:

TABLE 4.—*Production of contained antimony in antimonial lead ores and secondary antimony in the United States, 1948–52, in short tons*

Year	Antimony content in antimonial lead ores	Secondary antimony
1948	2,190	21,592
1949	1,214	18,061
1950	2,253	21,862
1951	1,663	23,943
1952	2,210	23,089

RESERVES [1]

[1] Materials Survey Antimony, ch. III, Resources, March 1951, pp. 1–57.

Besides the antimony deposits in the Yellow Pine district in Idaho, previously referred to, which constitute the largest reserves in the United States, there are a number of ore deposits, consisting essentially of quartz, stibnite, and antimony oxides, with only small or negligible content of gold, silver, and other metals, in several Western States. These deposits are mined primarily for their antimony content; therefore, production from them is closely related to antimony price. Most of these deposits are very small and individually are not reliable sources for the metal. The Stayton district in San Benito County, Calif., may be an exception to this generalization. Moderately large reserves also exist in the San Emigdio mine, Kern County, Calif.; the Wildrose Canyon district, Inyo County, Calif.; and the Antimony Canyon area, Garfield County, Utah. All of the latter, however, can be mined only when prices are exceptionally high or the need for antimony is unusually great.

Domestic reserves that can be mined when the price of antimony is less than 40 cents a pound contain about 20,000 tons of antimony. Additional reserves that can be mined when antimony is priced at 40 to 60 cents a pound contain

perhaps 30,000 tons of metal. The total reserves, including the above, that could be worked at prices of less than $1.50 a pound are highly uncertain, but a reasonable estimate is 80,000 to 100,000 tons of antimony. Within each price range, the Yellow Pine district contains at least half of the known reserves.

Western Hemisphere

Table 5 shows Western Hemisphere reserves by country. The figures are for a grade of 2 percent or higher for the simpler type of antimony deposit, and for all known reserves almost regardless of grade for the complex type.

TABLE 5.—*Western Hemisphere reserves of antimony*

	Short tons
Bolivia	550,000
Mexico	550,000
United States	100,000

CONSUMPTION

The total consumption of antimony in the United States in 1952 was 40,200 short tons, a decrease of 8 percent from the 43,700 tons consumed in 1951. Primary antimony used totaled 14,300 short tons (17,400 in 1951); antimony content of lead-silver ore consumed in the manufacture of antimonial lead by primary lead refineries, 2,800 short tons (2,400 in 1951); and secondary, 23,100 short tons (23,900 in 1951).

Consumption of primary antimony in the manufacture of finished products decreased 18 percent from 1951. Of the quantity consumed, 59 percent was used in the manufacture of nonmetallic products and 41 percent in the manufacture of metallic products.

Consumption of secondary antimony, chiefly in metallic products, decreased 3 percent in 1952.

Table 6 shows the industrial consumption of primary antimony in the United States, 1948–52, by type of material, in short tons, antimony content.

TABLE 6.—*Industrial consumption of primary antimony, 1948–52, by type of material, in short tons, antimony content*

	Ore and concentrates	Metal	Oxide	Sulfide	Residues	Total
1948 [1]						15,455
1949	2,472	4,163	4,492	139	(2)	11,266
1950	3,065	6,330	5,600	172	(2)	15,167
1951	3,007	4,645	8,872	162	684	17,370
1952	1,776	4,321	7,465	117	576	14,255

[1] Figures compiled by Office of Materials Distribution, U. S. Department of Commerce. Breakdown by type of material not available.
[2] Not reported separately.

PRICES

The price of antimony has been marked by notorious instability. The trend of antimony prices has been upward over a long period of years. During the World War II period the average price of antimony metal was about 15.5 cents. In 1952 quoted prices for antimony metal, New York City, ranged from a high of 52 cents early in the year to a low of 26.5 cents at the end. Average price for the metal during 1952, according to the American Metal Market, was 44.02 cents per pound compared with 44.17 cents in 1951.

Since late 1952 foreign antimony has been sold in this country at prices well below the quoted domestic prices. Table 7 presents the average price of antimony ore, by grade, July–December 1952, and January–June 1953.

TABLE 7.—*Average price of antimony ore, July–December 1952 and January–June 1953, by grade, per unit of contained antimony*

	1952						6-month average
	July	August	September	October	November	December	
50 to 55 percent	3.40	3.15	2.85	2.60	2.55	2.55	2.85
55 to 60 percent	3.45	3.30	3.10	2.90	2.80	2.75	3.05
60 to 65 percent	4.75	3.90	3.40	3.10	3.30	3.35	3.65

	1953						6-month average
	January	February	March	April	May	June	
50 to 55 percent	2.65	2.65	2.65	2.55	2.45	2.50	2.60
55 to 60 percent	2.80	2.80	2.80	2.70	2.55	2.70	2.75
60 to 65 percent	3.65	3.60	3.60	3.45	3.25	3.35	3.50

TARIFF

There is a duty of 2 cents a pound on imports of antimony metal (unchanged since December 11, 1950); 1 cent a pound on antimony oxide (unchanged since May 22, 1948) and one-half cent per pound, plus 12 percent of the foreign value, on antimony sulfide (unchanged since January 1, 1948). There is no duty on imports of antimony contained in ore.

FOREIGN TRADE

Imports

In 1952 the United States imported for consumption 12,800 tons of contained antimony, a decrease of 18 percent from the 15,700 short tons imported in 1951.

Of the total amount imported, 67 percent was supplied by countries in the Western Hemisphere; 29 percent by European countries (United Kingdom, Yugoslavia, Belgium-Luxembourg, and Czechoslavakia, predominating); 3 percent from the Union of South Africa; and 1 percent from Turkey. Table 8 presents general imports of antimony, by continents, 1948–52.

Exports

Exports of antimony ore and concentrates (gross weight) in 1952 were 25 tons valued at $13,300; and of metal and alloys, 136 tons valued at $124,400. During 1951, exports (gross weight) included 5 tons of antimony ore and concentrates valued at $5,100 and 160 tons of metal and alloy valued at $146,000.

Reexports of ore and concentrates in 1952 were 5 tons, valued at $3,400; and of metal and alloys, 1 ton valued at $1,000.

TABLE 8.—*General imports of antimony into the United States, 1948–52, in short tons, antimony content* [1]

	1948	1949	1950	1951	1952
Western Hemisphere:					
Bolivia	3,400	3,200	5,500	4,600	5,000
Canada	(2)	100	300	(2)	
Chile	100	500	900	500	100
Honduras	(2)	(2)		(2)	
Mexico	8,800	3,700	4,600	5,100	3,300
Peru	1,100	700	300	400	300
Total	13,400	8,200	11,600	10,600	8,700
Europe	400	1,000	3,400	2,700	3,700
Africa	100		100	2,100	300
Asia	3,300	400	200	(2)	100
Oceania			(2)		
Grand total	17,200	9,600	15,800	15,400	12,800

[1] Excludes imported antimony contained in lead-silver ores.
[2] Under 35 tons.

Source: Prepared by Base Metals Branch, Bureau of Mines, Oct. 14, 1953.

Senator MALONE. There was testimony yesterday by one of the principal past producers of antimony that through laboratory work and investigations new important uses of antimony are in sight. Could you, Mr. Johnson, give us an idea of what these uses are and perhaps some idea of the additional uses of that important metal?

Mr. JOHNSON. They seem to have considerable promise, Senator, although it is my understanding that they are still in the development and testing stage. If the development proceeds as hoped for, it will furnish a very welcome market for antimony metal; particularly I think the plating application would, if that became important. It would consume rather large quantities.

Senator MALONE. Is it a substitute or a displacement of some other metal?

Mr. JOHNSON. It would be in competition with other metals.

Senator MALONE. What metals?

Mr. JOHNSON. I do not know certainly, but I should think cadmium and zinc, for example, and chromium, possibly. The process is still rather new.

Senator MALONE. It might be a feasible method of saving chromium if that were necessary?

Mr. JOHNSON. That is just a guess on my part.

Senator MALONE. From the testimony of the producers, it would appear that a profitable mining process in almost any of these metals will result in a very marked increase in production. However, that is another question.

It was testified in addition to the plating process that low-cost antimony alloys could be used for transistors, rectifiers, and generally speaking in the electrical industry—do you know anything about that?

Mr. JOHNSON. If a transistor consisting of aluminum and antimony would replace one made of very costly minor metals, it would be a great advantage.

Senator MALONE. I wonder if we could request you to investigate further into this matter of new uses for antimony and submit for the record any additional conclusions you may reach in the matter of displacement of more costly materials by antimony?

Mr. JOHNSON. I would be very glad to do that.

Senator MALONE. I think it is very important. You know what the committee is charged to find out under what policy the United States could be assured of the availability of critical materials. Of course, one way is the substitution of more common materials for very scarce and high-priced materials. I think that would be very important. If you will do that job for us, as I know you can, because you have available sources of such information within your department. The committee is leaning heavily on your department, as you already know.

(The information is as follows:)

Two potential new uses for antimony have been mentioned recently in the technical press which, if successfully developed, would create significant demands on the available supply of the metal. One of these is in the field of electroplating, the other in electronics.

Antimony's silvery appearance and resistance to tarnish and corrosion have inspired numerous attempts to use it as a plating metal, but these have been defeated in the past by its brittleness and the difficulty of developing suitable plating techniques. In recent years, two methods have been described by which steel and other metals can be plated satisfactorily with antimony. It is reported that these coatings are adherent, ductile, and readily polished, comparing well

with nickel and chromium plate. Bradley Mining Co. is sponsoring research at Battelle Memorial Institute to perfect an antimony plating process, and it is believed that work along the same line is in progress in other laboratories. Should these investigations lead to industrial adoption of antimony plating, and if antimony were substituted to a significant extent for nickel and chromium, substantial tonnages would be required. A further consideration of importance, besides the increased demand for antimony, would be the saving of the more highly strategic metals in time of emergency.

A second new use for antimony was described in a report released in April 1953 by Battelle Memorial Institute, based on research also sponsored by Bradley Mining Co. This use was in a semiconductor alloy consisting of antimony and aluminum—about 70 percent antimony and 30 percent aluminum; it was believed this alloy might be equal, or superior in some respects, to the semiconductors of silicon or germanium that have become important in various electronic devices in recent years. Rectifiers for converting alternating to direct current, and transistors in place of vacuum tubes for detecting and amplifying radio signals, commonly contain semiconductors of silicon or germanium. The latter are much more difficult to obtain in the requisite purity than is antimony, and the supply of germanium is comparatively limited. In view of its relatively favorable cost and performance characteristics, the development of the new alloy will doubtless be followed to an early conclusion. Its potential impact on the requirements for antimony cannot be estimated.

CADMIUM

Senator MALONE. Now, passing on then to the cadmium that you have just mentioned, do zinc ores in this country generally contain cadmium?

Mr. JOHNSON. Yes; they do, Senator. I will try to bring that out. I believe there is a statement on it in the material that will be submitted. The quantity is quite variable; it is one of the things we are hoping to investigate more thoroughly in connection with the supply of cadmium. Most of the foreign ores we receive contain more cadmium than the average domestic ore.

Senator MALONE. Does the domestic producer separate the cadmium and sell it separately from the zinc?

Mr. JOHNSON. Yes, if it is present in sufficient amounts.

Senator MALONE. It is not difficult to process to recover it?

Mr. JOHNSON. I would say it is a rather expensive process.

Senator MALONE. What does it generally have to contain, however you express it, percentage or otherwise, to make it worthwhile?

Mr. JOHNSON. I cannot give you a definite figure.

Senator MALONE. It varies with various operations?

Mr. JOHNSON. As I say, all zinc concentrates contain some cadmium. If it is present to the extent of perhaps ten- to fifteen-hundredths of 1 percent, and in some instances even smaller quantities, then it becomes worth recovering.

Senator MALONE. That is the cadmium content at which they would then begin to take notice and try to separate it.

Mr. JOHNSON. It also depends on where the ore is being smelted.

Senator MALONE. Of course, local conditions would govern considerably. I just wanted an estimate. Do you have some further information on cadmium?

Mr. JOHNSON. Yes. One of the difficulties about the cadmium supply is that it is not responsive to the demand, being so closely tied to zinc production that the discovery of new uses and the increasing price resulting from demand do not automatically bring out more cadmium.

Senator MALONE. In other words, you do not mine cadmium alone. It is obtained merely as a byproduct of zinc mining.

Mr. JOHNSON. It is wholly a byproduct.

Senator MALONE. Then as the domestic production of zinc would decline, generally speaking that would affect the supply of cadmium, or would you separate the cadmium from the zinc concentrates that might be imported from abroad?

Mr. JOHNSON. That would be the case.

Senator MALONE. Would you do that?

Mr. JOHNSON. Yes, sir.

Senator MALONE. So the supply of cadmium would not be affected very much whether the zinc concentrates came from domestic or foreign sources unless it were separated and made into metal before it came here?

Mr. JOHNSON. We use about $16 million worth of cadmium a year, and about half of it is derived from domestic materials, about half from imported materials.

The strategic position of the metal is that if economies become necessary, they are feasible. You can substitute zinc for cadmium plating in many applications, even though it is less satisfactory and not so economical in the long run.

If I may, I should like to submit a further statistical statement on cadmium with a bit of information about those matters I have touched on, and charts similar to those for antimony could be attached thereto.

Senator MALONE. Yes. We have the charts supplied by your department. Chart No. 1 indicates the consumption of cadmium and average yearly price in dollars per pound. Most of the charts include that price simply to have some indication of what effect price has on production.

Chart No. 2, general imports, the source of such imports, showing the imports from Canada and Mexico outstrip all others.

Chart No. 3 is a general chart of the source from all foreign nations of the imports into the United States, and the United States production for 1949–52, inclusive.

These charts will be attached to your text submitted, and included in the record at this point as a part of your testimony.

(The information is as follows:)

CADMIUM

Cadmium is classified as a strategic and critical material and was in short supply during World War II and again in 1951. The Government regulated the cadmium industry during these periods, imposing restrictions on use, inventory controls, and priorities, in order to insure adequate supplies for all essential purposes. In 1952 increased production and record imports of metal overcame the shortage which began in mid-1950, consequently all control measures were rescinded. Domestic production of cadmium in January–August 1953 was at an all-time high rate and stocks accumulated to the highest level on record.

Salient statistics of the cadmium industry in the United States, 1948–52, in pounds of contained cadmium

	1948	1949	1950	1951	1952
Production (primary)	7,775,657	8,226,617	9,190,394	8,311,337	8,567,159
Imports (metal)	9,809	157,204	630,109	90,065	1,478,770
Exports (metal)	955,701	566,135	352,927	606,233	300,918
Consumption, apparent	7,797,105	7,486,274	9,545,502	7,170,930	9,042,052

Salient statistics of the cadmium industry in the United States, in January–July 1953, in pounds of contained cadmium

1953	Production (primary)	Imports (metal)	Exports (metal)	Apparent consumption
January	791,000	200,000		762,000
February	723,000	102,000	6,000	754,000
March	814,000	158,000	4,000	1,001,000
April	829,000	117,000	8,000	987,000
May	835,000	83,000	10,000	844,000
June	853,000	183,000	4,000	1,027,000
July	897,000	153,000	5,000	855,000

Cadmium is a metal of specialized uses where its superior performance has developed a strong and expanding demand. It is used chiefly in electroplating, bearing alloys, and pigments; about 95 percent of available cadmium is consumed for these purposes, with electroplating by far the largest use. Cadmium is used as a protective coating for iron and steel, and, to a much smaller extent, other metals and alloys on a wide variety of products including aircraft, ordnance, and automobiles. Copper-cadmium alloys containing about 1 percent cadmium have found wide use in telegraphic, telephonic, and power-transmission lines since cadmium imparts great durability and good tensile strength, hardness, and high annealing temperature, and does not impair the conductivity of copper to any harmful extent. Other uses of the metal are for solders, low-melting-point alloys for fire-control apparatus, and other purposes and miscellaneous alloys. Cadmium is also used in long-life nickel-cadmium storage batteries and (in small quantities) in atomic-energy development where it is used to control the fissionable elements in reactors.

Cadmium can be replaced by other materials, particularly zinc, in many plating applications. In salt water and tropical atmospheres, however, cadmium is generally considered more satisfactory than zinc. Moreover, most substitute metals lack the throwing power of cadmium for electroplating odd shapes and parts; and where close tolerances are required there is no substitute for cadmium. Intricately shaped moving-part fuses with rigid tolerances are plated with cadmium, for example. Metal parts that come in contact with cloth and rope, such as parachute buckles, are coated with cadmium as zinc reacts with the material and rots it.

There are no commercial ore reserves of cadmium. The entire supply of primary metal is (and always has been) recovered as a byproduct of the treatment of ores of other metals, particularly zinc, hence cadmium reserves depend largely upon the size of zinc ore reserves and the cadmium content of these reserves. Recent estimates of domestic reserves placed the recoverable cadmium in domestic reserves of zinc ore of all classes (measured, indicated, and inferred) at approximately 100 million pounds. In the United States the average yield of zinc ores is about 5.5 pounds of recoverable cadmium per ton of recoverable zinc. Some foreign ores contain much greater cadmium values; in Mexico the yield is as high as 14–15 pounds of cadmium per ton of zinc.

The United States is the world's leading producer of cadmium; for the period 1940–52, production at domestic plants accounted for approximately two-thirds of the total world output. United States production, however, is not solely from domestic materials; it is estimated that about 50 percent of the primary cadmium produced in the United States is of foreign origin. Mexico is the chief foreign source, followed by Canada and Peru. Of the total apparent consumption of cadmium in the United States during the 13 years 1940–52, domestic production furnished about 50 percent and Mexico, Canada, and South America nearly 50 percent. Thus it is apparent that while domestic production is insufficient for total United States requirements, practically all of the additional supplies needed for civilian and military purposes could be obtained from Western Hemisphere countries. Moreover, it appears that the United States could count on enough cadmium to satisfy absolutely essential needs even if forced to rely on domestic resources alone. Widespread substitution for cadmium in electroplating and curtailment of consumption for all nonessential uses would be necesssary in the event such a situation were prolonged.

Production of primary cadmium, including cadmium compounds made from primary raw materials at United States plants averaged 8,400,000 pounds per year for the period 1948–52. Apparent consumption, including large quantities purchased for the national stockpile, averaged 8,200,000 pounds annually over the same period. Cadmium, incidentally, was one of the several commodities listed by the Munitions Board at the end of calendar 1952 as having been accumulated to a point where completion of the objective was "no longer of the highest urgency."

Prices for commercial sticks of cadmium have been relatively stable since 1948, ranging from a low yearly average of $1.83 a pound in 1948 to $2.55 a pound in 1951. In August 1952 the price dropped to $2, at which level it has remained through September 1953. Price changes do not have any great effect on the supply of cadmium because of cadmium's byproduct relationship to zinc and other metals.

Because of the byproduct relationship of cadmium to zinc, virtually the only practical means of increasing the output of cadmium is to achieve greater efficiency in recovery of cadmium in the smelting and refining of zinc. Moreover, the declining productivity of the Tri-State district relative to other districts tends to decrease cadmium recovery inasmuch as the Tri-State ores are richer in cadmium than most other domestic ores.

While the quantity of cadmium recovered per ton of zinc has increased markedly during the past 15 years, due to installation of more cadmium recovery facilities, the prospect of a further substantial increase is considered unlikely. Such increases as will come from installation of additional recovery units and from improving the efficiency of existing units will probably not exceed 10 to 15 percent of present production.

It is conceivable that sizable quantities of cadmium could be recovered from zinc metal. The lower grades of slab zinc contain from 0.2 to 0.7 percent cadmium and if only a portion of this cadmium were recovered a substantial output would be obtained. It is questionable, however, that the return realized from such cadmium recovery would compensate for the cost of obtaining it.

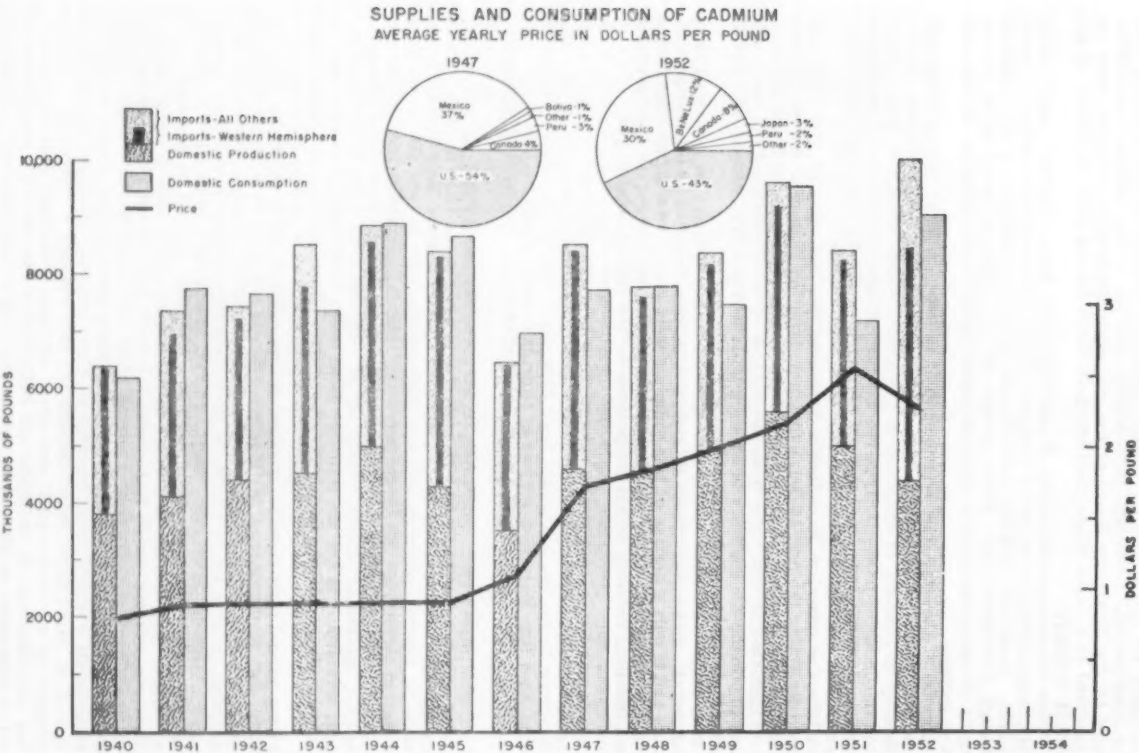
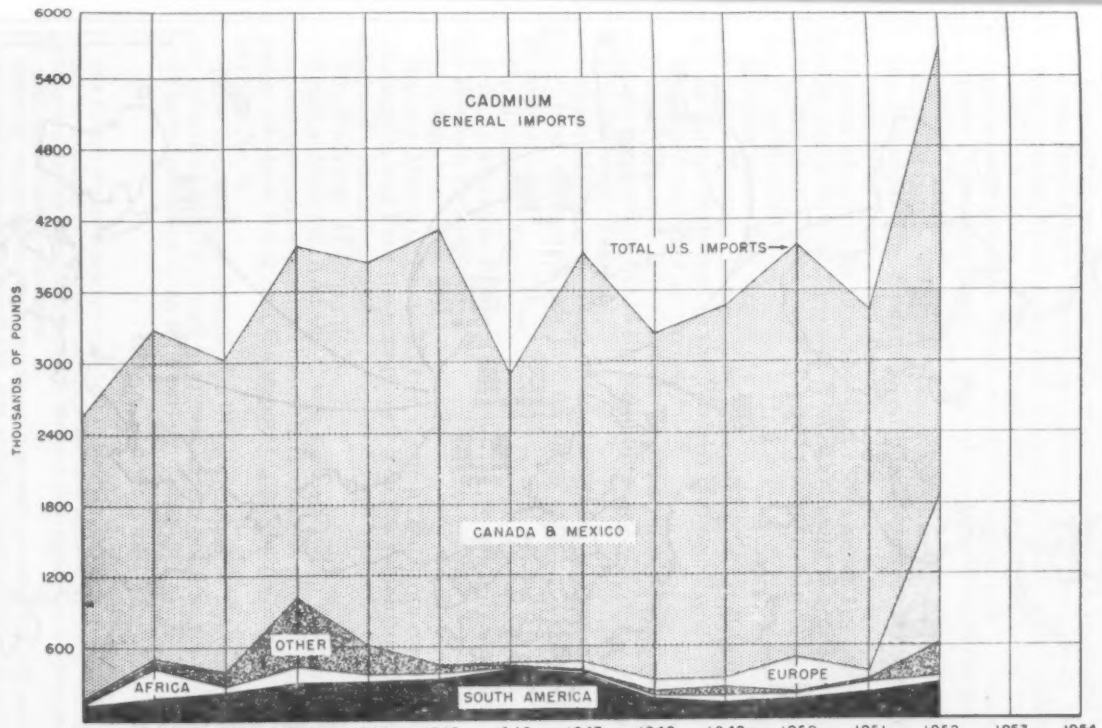

SUPPLIES AND CONSUMPTION OF CADMIUM
AVERAGE YEARLY PRICE IN DOLLARS PER POUND
1947
1952
Mexico 37%
Bolivia-1%
Other -1%
Peru -3%
Canada 4%
U S - 54%
Mexico 30%
Belgium 12%
Canada 8%
Japan - 3%
Peru - 2%
Other - 2%
U S - 43%
Imports - All Others
Imports - Western Hemisphere
Domestic Production
Domestic Consumption
Price
THOUSANDS OF POUNDS
DOLLARS PER POUND
10,000
8000
6000
4000
2000
0
3
2
1
0
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

Figure 1



Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2

Prepared by United States Department of the Interior, Bureau of Mines

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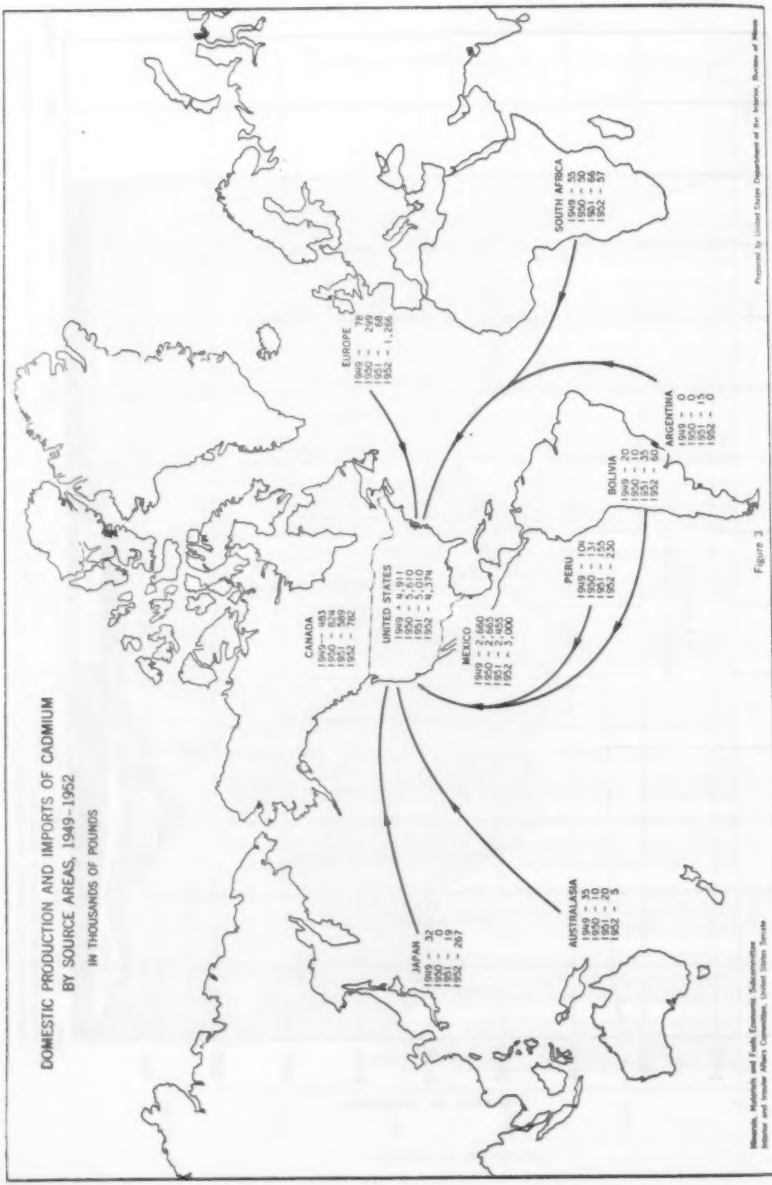

DOMESTIC PRODUCTION AND IMPORTS OF CADMIUM
BY SOURCE AREAS, 1949–1952
IN THOUSANDS OF POUNDS
CANADA
1949 – 483
1950 – 824
1951 – 989
1952 – 782
UNITED STATES
1949 – 4,911
1950 – 5,610
1951 – 5,010
1952 – 4,374
MEXICO
1949 – 2,240
1950 – 2,665
1951 – 2,455
1952 – 3,000
EUROPE
1949 – 76
1950 – 269
1951 – 559
1952 – 1,266
SOUTH AFRICA
1949 – 55
1950 – 90
1951 – 56
1952 – 57
ARGENTINA
1949 – 0
1950 – 0
1951 – 15
1952 – 0
BOLIVIA
1949 – 20
1950 – 10
1951 – 35
1952 – 60
PERU
1949 – 104
1950 – 71
1951 – 155
1952 – 230
JAPAN
1949 – 32
1950 – 0
1951 – 19
1952 – 267
AUSTRALASIA
1949 – 35
1950 – 10
1951 – 20
1952 – 3
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

Figure 3

BISMUTH

Mr. JOHNSON. With reference to bismuth, it is one of the less important base metals on a dollar basis, about $3 million a year, and yet it has a number of very important industrial uses, because of its low melting features, and the fact that it expands slightly on solidification. It is used in a number of very important alloys, solders, and so forth. We are not self-sufficient in this country as to bismuth. A considerable part of our requirement is obtained as a byproduct of the smelting of imported materials.

Senator MALONE. What is the source of those imports?

Mr. JOHNSON. The Western Hemisphere largely. We also import the metal itself from Latin America.

Senator MALONE. In 1952, the chart shows about 1½ percent from Europe and a half of 1 percent from Asia, and the remainder, about 49 percent from United States, Peru 33 percent, and so on. Does that sound reasonable?

Mr. JOHNSON. Yes, sir.

Senator MALONE. It means we are entirely self-sufficient as far as any amount is concerned in the Western Hemisphere.

Mr. JOHNSON. That is correct.

Senator MALONE. The chart shows some years where the information was not available as to the consumption.

Mr. JOHNSON. Yes, sir.

Senator MALONE. So I am unable to determine from the chart exactly how dependent we are on other nations in the Western Hemisphere.

Mr. JOHNSON. Yes, sir.

Senator MALONE. But it is correct that we are fully supplied from the Western Hemisphere.

Mr. JOHNSON. Yes.

Senator MALONE. I note Mexico is one of the large contributors to our supply, and Peru the remainder. You are submitting this text as a part of your testimony?

Mr. JOHNSON. If I may do so.

Senator MALONE. And the charts as described in the other metals, supplies and consumption of bismuth, the source, general imports, and source on chart No. 2, and the imports from the nations of the world in chart No. 3.

Those charts I just described will be attached to the text, and both are submitted for the record to appear at this point in your testimony.

(The information is as follows:)

BISMUTH

The United States is not self-sufficient in bismuth, as much of the metal it consumes is imported or derived from imported raw materials. Peru, Mexico, and Bolivia are its chief suppliers, and the Western Hemisphere as a whole produces more bismuth than it consumes.

Essential requirements for bismuth are now well provided for. If large additional supplies could be assured new uses probably would develop, but as bismuth is almost wholly a byproduct of lead, silver, copper, and other metal production, no practicable means are apparent to bring about a large increase in output.

During the past 20 years bismuth has become an important industrial material through the development of its alloys. Prior to this period the chief uses for bismuth were in the production of pharmaceutical salts and in the low-melting solders used in devices such as sprinkler-head links and other fire-prevention equipment. Experimentation and research now have developed many new uses for the bismuth alloys. Today there are more than 70 known useful ways of employing them.

DESCRIPTION AND PROPERTIES

Bismuth is a white metal of high luster having a distinct pinkish tinge. It is coarsely crystalline and very brittle.

Salient statistics of bismuth metal, 1948–52, in thousand pounds

	1948	1949	1950	1951	1952
Consumption	[1] 1,400.0	[1] 1,400.0	[1] 1,500.0	1,592.0	1,775.0
General imports [2]	300.0	542.0	782.0	514.0	708.0
Exports of metal and alloys	352.0	191.0	199.0	147.0	245.0
World production	3,300.0	3,300.0	3,080.0	3,740.0	3,960.0
Average price per pound [3]	2.00	2.00	2.06	2.25	2.25

[1] Estimated.
[2] Excludes imports of bismuth contained in bismuth-lead bars from Mexico; also excludes imports of bismuth contained in concentrates.
[3] Engineering and Mining Journal, Metal and Mineral Markets.

Pure bismuth melts at 271° C., and imparts low-melting characteristics to alloys with various other metals. It expands 3.32 percent during solidification, this unusual property accounting for some of its most useful applications.

USES

Bismuth is much too brittle to be used alone. Its alloys are used for sprinkler plugs and other fire-protective devices, electrical fuses, low-melting solders, dental amalgams, and tempering baths for small tools. In most of these alloys the function of the bismuth is to lower the melting point. Bismuth improves the casting properties of tin and lead by lowering the surface tension, thereby producing sharply defined castings even when the percentage of bismuth (or antimony) is insufficient to cause the metal to expand and fill the mold at the moment of solidification. Bismuth also acts as a hardening agent.

One of the major uses of bismuth has been in the form of its compounds which are extensively used in medicinal and cosmetic preparations, including various indigestion remedies and toilet powders. A number of the compounds are used in treating wounds and the metal is therefore of some importance in time of war. Insoluble salts of bismuth are given to patients preparatory to X-ray examination of the digestive tract. Minor amounts of bismuth compounds have been used in porcelain painting, in enameling, and in optical-glass manufacture.

In addition to extremely small amounts of metallic bismuth to molten iron, both gray and white iron is made to produce cleaner castings. The bismuth addition produces greater fluidity of the liquid.

Addition of bismuth to certain aluminum alloys is a regular established procedure and the Aluminum Co. of America and others produce alloys that contain 0.5 percent bismuth and 0.5 percent lead for free-cutting screw-machine stock. Small amounts of bismuth added to corrosion-resistant steels produce castings of greatly improved machinability.

The research department of the General Electric Co. has developed an alloy of bismuth, lead, tin, and antimony, known as Cerromatrix, for the purpose of anchoring complex punches and dies used in the cutting operations in producing electric-motor laminations. Cerromatrix and other low-temperature-melting alloys also are widely used in the production of dies and punches for short-run forming of sheet metal. The aircraft industry has been a heavy user of some of these alloys.

Spray guns, heated by gas or electricity, operating with compressed air have been designed for use with low-melting alloys. Several of the bismuth alloys can be sprayed like paint and a number of useful applications have developed as a result. To protect wooden foundry patterns from wear, warpage, and

cracking, a thin layer of a low-temperature-melting alloy, about 0.003 inch thick, can be quickly applied to the surface.

One of the relatively new uses for bismuth is in the dyeing industry. The Standfast molten metal continuous dyeing process is a recent development which is expected to expand the use of bismuth. The Standfast process is a complete departure from the traditional methods in dye techniques. In this process, heat and pressure are applied by molten metal (bismuth) in which dye-impregnated fabric is immersed.

The United States Atomic Energy Commission now holds patents for five alloys containing bismuth, lead, tin, and gallium. They have been patented because their low melting points and low neutron capture qualities make them suitable for coolants for atomic piles. The AEC also holds patents to three alloys containing bismuth, lead, tin, and thallium.

OCCURRENCE

Bismuth is rather an uncommon element. Bismuth frequently occurs native and the native metal and the sulfide, bismuthinite (Bi_2S_3), are its chief ore minerals.

Bismuth occurs most commonly as a minor constituent of lead ores, and less importantly in gold, copper, and tungsten ores, hence is recovered commercially to a very large extent as a byproduct.

WORLD PRODUCTION

The world output of bismuth is from 1,900 to 2,000 short tons annually. In 1952, the world's production of bismuth increased 6 percent compared with 1951. Of the total output, North America supplied 47 percent; South America, 19 percent; Europe, 25 percent; Asia, 9 percent; Africa and Australia, negligible.

The principal foreign sources, in order of their importance, are the copper, lead, and silver deposits of the Cerro de Pasco district, Peru; the lead deposits of Mexico; and the tin and tungsten deposits of Bolivia. A large tungsten mine in the Province of Kangwon, southern Korea, in operation during the last year and a half of World War II, had a byproduct yield of bismuth intermediate between that of Peru and Mexico. Minor supplies come from Argentina, Chile, Brazil, and Canada. Long-accumulated Canadian stocks of bismuth-bearing residues from refineries were treated during World War II to help meet needs of the United Nations.

DOMESTIC PRODUCTION

In the United States, native bismuth or bismuthinite ores have never been found to be of major importance. Minor occurrences of these ores have contributed relatively small tonnage of bismuth. The major domestic sources are the lead-silver ores of Utah and Colorado, and the copper and lead ores of Montana, Utah, Nevada, Arizona, Idaho, and New Mexico.

Bismuth producers in the United States are the American Smelting & Refining Co. (AS&R), Omaha, Nebr., and Perth Amboy, N. J.; Anaconda Copper Mining Co., Anaconda, Mont.; and the United States Smelting, Refining, & Mining Co., East Chicago, Ind.

Most of the bismuth produced in the United States is obtained as a byproduct from the smelting of domestic and foreign lead ores and by the refining of imported bismuth bars containing lead as a major impurity. The Bureau of Mines is not at liberty to divulge the quantities produced, but 1952 output declined 5 percent compared with 1951.

RESERVES

The reserves of bismuth in the United States, that are available under present economic and technologic conditions, can be roughly estimated from the average production life of the principal classes of deposits from which it is now recovered. Improvements in efficiency of recovery would increase the quantity of available bismuth somewhat, but not the life of the reserves, since the output of bismuth is controlled by demands for its companion metals. Based upon present recovery and estimates of commercial base metal reserves, the reserves of available bismuth metal are considered to be about 30 million to 50 million pounds. Material available under improved economic and technologic conditions probably exceeds those quantities. The largest sources of such material are those gold veins from which bismuth is not recovered at present and submarginal base-metal deposits containing bismuth.

CONSUMPTION

Demand for bismuth, particularly in the form of refined metal, was firm in 1952. Its use in pharmaceuticals was the lowest on record reflecting the continuing trend toward the antibiotics and kaolin-base preparations which have replaced bismuth compounds to some extent since World War II. The following table presents bismuth metal consumed in the United States in 1951–52, by major uses:

Bismuth metal consumed in the United States in 1951–52, by uses

Uses	1951 [1]		1952	
	Pounds	Percent of total	Pounds	Percent of total
Pharmaceutical	569,600	36	407,000	23
Solder	100,200	6	146,000	8
Fuse alloys	186,800	12	262,000	15
Manufacturing alloys	513,400	32	871,000	49
Other and unspecified alloys [2]	222,000	14	89,000	5
Total consumption	1,592,000	100	1,775,000	100

[1] February through December only; compiled by National Production Authority, Department of Commerce.
[2] Principally rectifier coatings.

A table presenting percentage distribution of bismuth in the United States follows:

Percentage distribution of bismuth in the United States 1948–52, by major use groups

Major use groups	1948	1949	1950	1951	1952
Pharmaceuticals	49	31	36	36	23
Metal and alloys [1]	51	69	64	64	77

[1] Principally fabricating alloys but includes pure metal, ammunition solder, fuse alloys, aluminum alloys and other minor compositions.

PRICES

The New York price for refined bismuth metal remained unchanged at $2.25 per pound in ton lots throughout 1952, according to the Engineering and Mining Journal, Metal and Mineral Markets. The following table presents the high and low prices of bismuth since 1940:

High and low prices of bismuth, per pound, wholesale, pharmaceutical grade, New York, 1940–52

Year	High	Price	Low	Year	High	Price	Low
1940		1.25		1947	2.00		1.80
1941		1.25		1948		2.00	
1942		1.25		1949		2.00	
1943		1.25		1950	2.25		2.00
1944		1.25		1951		2.25	
1945		1.25		1952		2.25	
1946	1.80		1.25				

TARIFF

The tariff on refined bismuth metal was reduced from 3¾ percent to 1⅞ percent effective October 1951, as a result of the Torquay agreement. Paragraph 22, Tariff Act of 1930 provides that on chemical compounds and salts of bismuth the duty is 35 percent ad valorem. On bismuth alloys the duty is 22½ percent ad valorem. Bismuth ores are not dutiable.

FOREIGN TRADE

Imports

Receipts of refined metal in 1952 showed a rise of 38 percent above 1951. The approximate percentage distribution of receipts by countries of origin was: Peru 93, Yugoslavia 5, and Korea 2 percent. There were no transactions in chemical compounds, mixtures, and salts of bismuth in 1952.

Exports

Exports of bismuth alloys increased 67 percent in 1952. The United Kingdom was again the principal recipient taking 208,151 pounds; Australia received 11,200 pounds; West Germany, 9,703 pounds; and Canada, 2,492 pounds. Exports of bismuth salts and compounds totaled 233,211 pounds, valued at $741,265.

Bismuth metal and alloys imported into and exported from the United States, 1943–47 (average) and 1948–52

[U. S. Department of Commerce]

Year	Imports of refined metallic bismuth [1]		Exports of metal and alloys	
	Pounds	Value	Pounds	Value
1943–47 (average)	386,444	$418,692	107,161	$158,789
1948	299,824	464,734	352,027	711,354
1949	541,852	833,940	190,882	356,576
1950	781,670	1,287,098	199,253	387,458
1951	514,020	1,003,285	146,998	376,246
1952	708,254	1,451,729	244,797	625,260

[1] Excludes imports of bismuth contained in bismuth-lead bars from Mexico, also excludes imports of bismuth contained in concentrates.

Source: Prepared by Base Metals Branch, Bureau of Mines, Oct. 14, 1953.

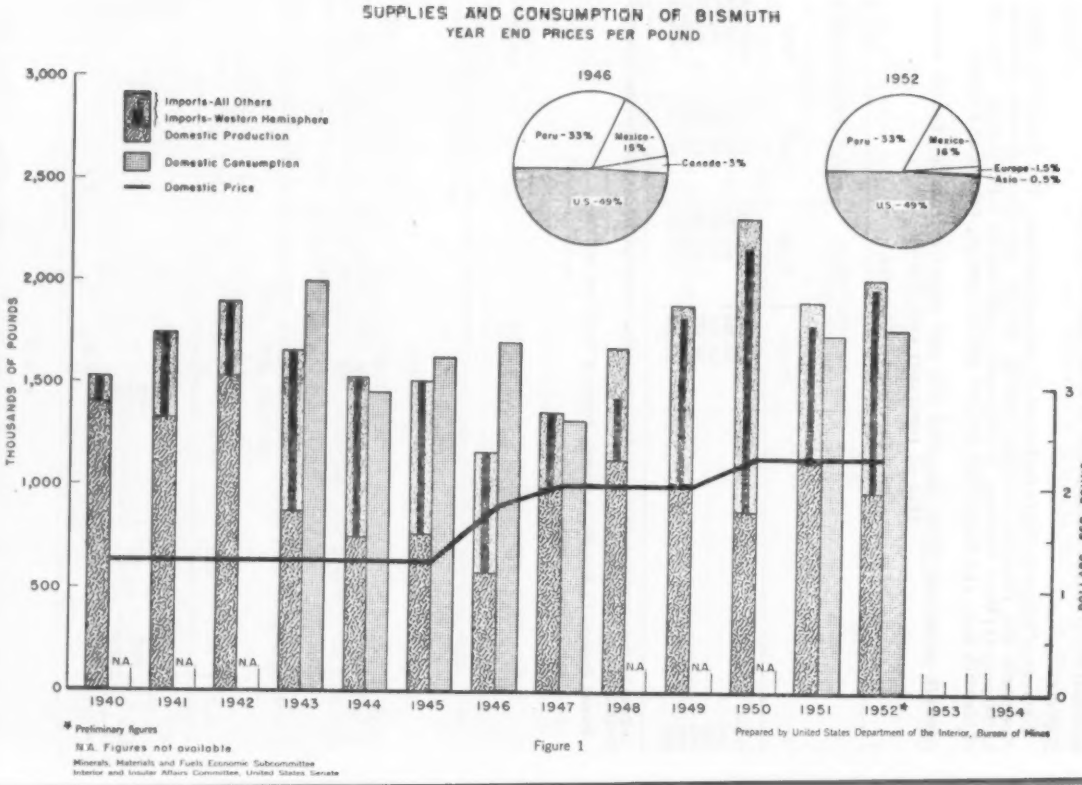
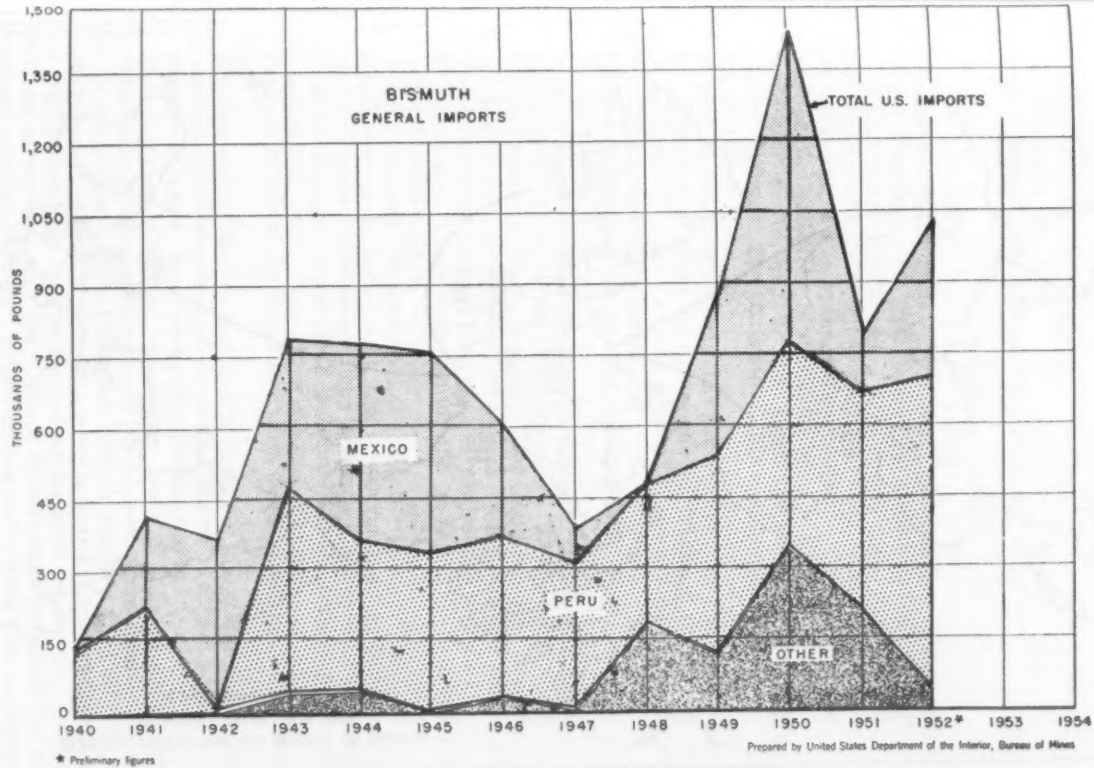

SUPPLIES AND CONSUMPTION OF BISMUTH
YEAR END PRICES PER POUND
Imports-All Others
Imports-Western Hemisphere
Domestic Production
Domestic Consumption
Domestic Price
1946
Peru - 33%
Mexico - 15%
Canada - 3%
U.S. - 49%
1952
Peru - 33%
Mexico - 16%
Europe - 1.5%
Asia - 0.5%
U.S. - 49%
THOUSANDS OF POUNDS
DOLLARS PER POUND
3,000
2,500
2,000
1,500
1,000
500
0
3
2
1
0
N.A.
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952*
1953
1954
* Preliminary figures
N.A. Figures not available
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

Figure 1

N.A. Figures not available

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

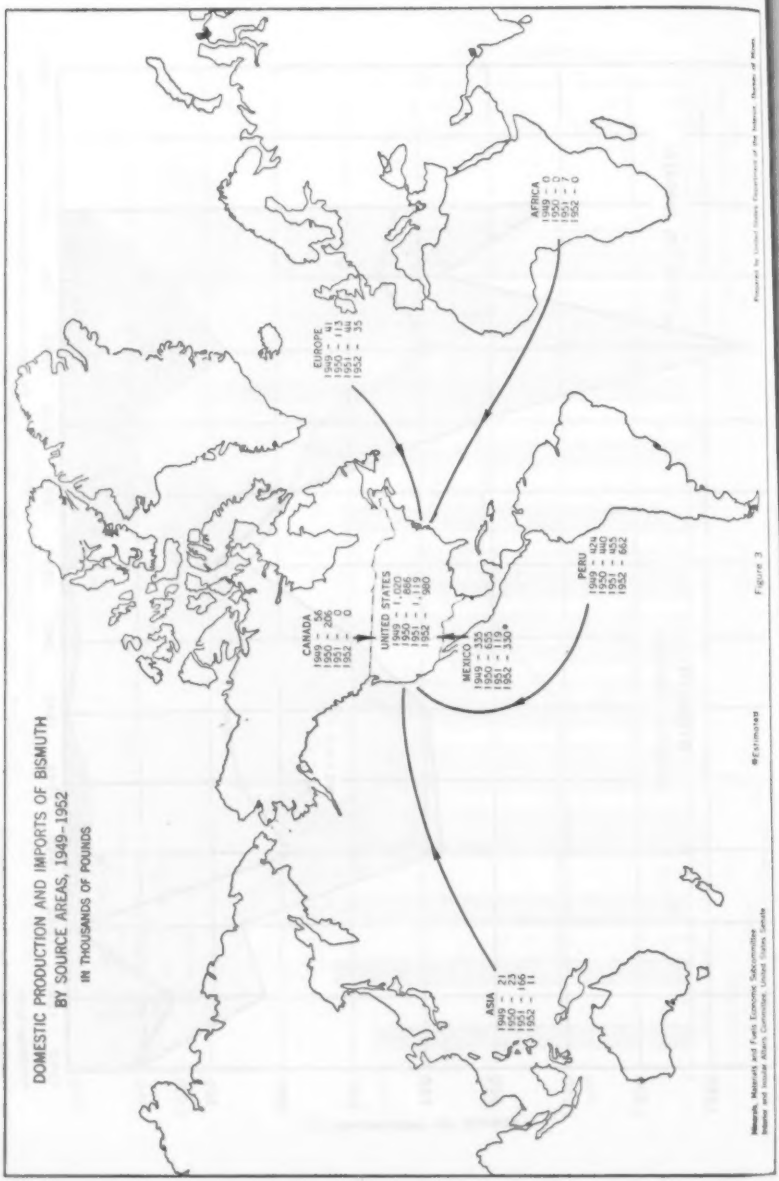
Figure 1



* Preliminary figures

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2


DOMESTIC PRODUCTION AND IMPORTS OF BISMUTH
BY SOURCE AREAS, 1949–1952
IN THOUSANDS OF POUNDS
EUROPE
1949 – 41
1950 – 111
1951 – 44
1952 – 35
AFRICA
1949 – 0
1950 – 0.7
1951 – 0
1952 – 0
CANADA
1949 – 56
1950 – 206
1951 – 0
1952 – 0
UNITED STATES
1949 – 1,020
1950 – 1,680
1951 – 1,119
1952 – 980
MEXICO
1949 – 35
1950 – 635
1951 – 119
1952 – 350*
PERU
1949 – 420
1950 – 420
1951 – 455
1952 – 662
ASIA
1949 – 21
1950 – 23
1951 – 16
1952 – 11
*Estimates
Figure 3

Senator MALONE. I would like to ask you at this time: In the text submitted is the dollar value of the metal consumed in the United States included?

Mr. JOHNSON. I have given that as a rough figure for each of these commodities.

Senator MALONE. In the text?

Mr. JOHNSON. Yes.

Senator MALONE. Be sure to cover the dollar value.

COPPER

Mr. JOHNSON. The dollar value of the consumption of new refined copper in the United States is about $600 million in the past 5 years. That is an average figure.

Senator MALONE. $600 million per year?

Mr. JOHNSON. Yes, sir; that is new copper.

Senator MALONE. New copper mined in the United States?

Mr. JOHNSON. No, sir; our total consumption.

Senator MALONE. Our total consumption of new copper.

Mr. JOHNSON. Yes.

Senator MALONE. What was that price range over the last 5 years?

Mr. JOHNSON. Twenty to 24½ cents; 22 cents, I think, was the average figure I used. As you know, the price was under control much of the time at 24½ cents.

Senator MALONE. That was the ceiling price.

Mr. JOHNSON. Yes.

Senator MALONE. Was the foreign price set at the same time?

Mr. JOHSON. That copper price situation is a very complicated one.

Senator MALONE. Was not the price on Chilean copper fixed by the State Department or some other Government agency? Didn't the copper from Chile account for practically all of the imports?

Mr. JOHNSON. There were limitations on the price that could be paid for foreign copper.

Senator MALONE. What was that limitation?

Mr. JOHNSON. It varied. At first it was the same as for domestic copper, if I am not mistaken. Then it became apparent that we would not get the foreign copper on those terms, and the foreign price ceiling was raised.

Senator MALONE. Do you know what the greatest price amounted to?

Mr. JOHNSON. I believe that was 30 cents. I have a statement there in the text to be submitted, if you would like to have that read.

Senator MALONE. Read that particular part of it.

Mr. JOHNSON. Ceilings for copper were established under the general ceiling price regulations at the highest prices received by individual producers from December 1950 to January 25, 1951. Since most copper had been sold at 24½ cents a pound delivered Connecticut Valley that price became the ceiling for most producers. In mid-1951 an agreement with the Chilean Government provided for the payment of 27½ cents for Chilean copper and a little later all copper refined from foreign materials was permitted the 27½-cent price.

In mid-1952, importers were permitted to pay whatever prices they wanted for foreign copper, and to pass on to customers 80 percent of the increased cost. Meanwhile under provisions of the Defense Production Act, the Government had entered into agreements with companies to purchase at negotiated prices production from expansion projects. That is speaking of domestic companies.

Also they entered over-the-ceiling, maintenance-of-production agreements with high-cost producers. These various actions led to wide-range multiple prices for copper and to considerable confusion. Price controls for copper were abandoned in February 1953. By the end of March the price for most of the domestic production settled at 30 cents a pound, which prevailed until October 1953, with custom smelters quoting 1 or 2 cents less. Chilean copper meanwhile advanced to 35½ cents a pound in Chile, about 36½ in the United States. But prices of other foreign copper approximated the domestic level.

Senator MALONE. You mentioned the 36½ cents per pound. Where did that 36½ cents per pound originate? Was it a ceiling price fixed by some department of Government that might be paid to all foreign producers or to only certain foreign producers?

Mr. JOHNSON. That related only to Chilean copper.

Senator MALONE. And they could pay 36½ cents or they did pay 36½ cents a pound for Chilean copper?

Mr. JOHNSON. Yes, sir. I might say that copper from other sources brought even higher prices at times in smaller quantities. There was a period when small quantities of copper from foreign sources brought much higher prices. Those figures are not known in detail.

Senator MALONE. Do you have some indication of those prices in your text?

Mr. JOHNSON. No, sir. We have no factual information on it. That was a small tonnage that did not have much effect on the average price.

Senator MALONE. Let the record show that Mr. Dawson, from Utah, is here at the hearing. Would you move up to the table? We hope to accommodate you very soon.

Then the price ranged from our ceiling price of 24½ cents to the Chilean price of 36½ cents a pound.

Mr. JOHNSON. Yes, sir. In addition to primary copper we consume almost 1 million tons a year of secondary copper. This is obtained from new and old scrap. Our new copper is made up of 3 principal elements; refinery production from domestic materials accounts for 70 percent; refinery production from imported materials, 20 percent, and imports of refined copper an additional 10 percent. On that basis we produce about 70 percent of our new copper domestically. This copper goes into the manufacture of electrical products, about 25 percent; light and power, telephone and telegraph, radio and television is about a fifth; the automobile and building industries both use about a tenth, or make a total of another fifth. Almost 86 percent of United States imports came from Western Hemisphere countries, and almost 60 percent from Chile alone. This country has very large reserves of copper, estimated at about 25 million tons. Canada and Mexico are believed to have about a third as much. We do not have a figure for Chile's reserves, but they are known to be very large, and are of better grade than those in the United States. Peru has several million tons of copper in explored deposits.

Thus the current rate of Western Hemisphere production does not threaten to exhaust its reserves rapidly, and could, if necessary, be considerably expanded. The same can be said of the reserve situation in Africa where the ore is considerably richer than even in Chile.

That, sir, I think is all I wish to say about copper unless you have further questions. I will submit a statement giving some background information to which those charts might very well be attached.

Senator MALONE. Yes. The three charts prepared by the United States Department of Interior, Bureau of Mines, show supplies and consumption of copper in chart 1, showing the domestic production, and the imports from the countries in the Western Hemisphere, and imports from other foreign nations, and also showing the annual consumption from 1940 to 1952, inclusive.

Chart No. 2 shows the source of imports, South America, North America, Africa, Asia, Australia, and Europe, showing at a glance that the bulk of our imports come from South America, Chile.

Chart No. 3, domestic production and imports of copper by source areas. That includes all foreign nations?

Mr. JOHNSON. Yes, sir.

Senator MALONE. Those three charts will be attached to your text and submitted as a part of the record at this point.

(The information is as follows:)

COPPER

The United States depends on imports for about a third of its requirements of new copper. The Western Hemisphere, however, produces enough new copper for all its needs and has a small exportable surplus. Reserves in the United States and other Western Hemisphere countries could if necessary support a higher rate of production.

United States mine production of recoverable copper (925,000 short tons) was 31 percent of total world production in 1952 and was equal to about 68 percent of United States consumption of new copper. United States known reserves are estimated as about 25 million tons, or 27 times the 1952 production: new discoveries and new technology are expected to add many millions of tons of copper to these reserves in coming years.

Of the large quantity of copper imported into the United States in 1952 (619,000 tons), 86 percent came from Western Hemisphere countries (58 percent was from Chile). Total United States receipts of unmanufactured copper increased 53 percent in the first 7 months of 1953 as compared with the same period in 1952. Of the 1953 total, 78 percent was from Western Hemisphere countries (48 percent was from Chile). The decline in 1953 was caused by the higher prices that prevailed for Chilean copper as compared with those for metal from other sources. Meanwhile United States mine production in January–July 1953 (541,000 tons) was virtually unchanged from the same months of 1952.

Canada, Mexico, and the United States in 1952 mined 41 percent of the world total, equal to 83 percent of North American requirements. Total North American reserves on the order of 32 million to 33 million tons, are 25 times North American production at the 1952 rate.

Chile's reserves are undisclosed but unquestionably very large. Peru has several million tons fairly well explored. It is estimated that total Western Hemisphere reserves are 35 to 40 times the Western Hempishere 1952 production of 1,750,000 tons. This production, incidentally, was 58 percent of the world total and roughly 125,000 tons, or 8 percent, in excess of Western Hemisphere consumption.

There are more large copper deposits in the United States than in any other country. In most other important copper-producing countries, production is highly concentrated in from one to not more than a few large properties. Even in the United States 87 percent of the output came from 8 leading districts in 1952; 44 percent came from 2 districts almost entirely from 2 open-pit mines. Ninety-three percent of Chilean production came from 3 mines in 3 districts, 4 large mines supplied the Northern Rhodesian total, the properties of 1 company operating in a relatively concentrated area along the borders of Belgian Congo

and Northern Rhodesia supplied all of the copper from the former country, and 87 percent of Canada's total came from 3 mines in 3 Provinces.

The most promising areas in the United States for possible new production have been the subjects of repeated investigations by private interests and by the Government. Since the outbreak of war in Korea, Government assistance has resulted in the development and exploitation of many deposits that had not been attractive under previous conditions. Such large deposits as San Manuel, Bisbee East (Lavender Pit), Bagdad, Silver Bell, and Copper Cities, in Arizona; White Pine, Mich.; Yerington, Nev.; and numerous smaller ones, have expanded production, have begun to produce or will do so within the next 2 or 3 years as a result of this unusual stimulation. However, there are still some incompletely explored deposits of considerable potential size, and if economic circumstances warranted, known domestic deposits could be developed and equipped to produce copper at a much higher rate than is now regarded as profitable and desirable.

PRICES

Ceilings for copper were established under the general ceiling price regulation at the highest prices received by individual producers from December 19, 1950, to January 25, 1951. Since most copper had been sold at 24½ cents a pound, delivered Connecticut Valley, that price became the ceiling for most producers. In mid-1951 an agreement with the Chilean Government provided for the payment of 27½ cents for Chilean copper and a little later all copper refined from foreign materials was permitted the 27½-cent price. In mid-1952 importers were permitted to pay whatever prices they wanted for foreign copper and to pass on to customers 80 percent of the increased costs.

Meanwhile under provisions of the Defense Production Act the Government had entered into agreements with companies to purchase at negotiated prices production from expansion projects, and also had entered into over-the-ceiling maintenance-of-production agreements with high-cost producers.

These various actions led to wide-range multiple prices for copper and to considerable confusion.

Price controls for copper were abandoned in February 1953. By the end of March the price for most of the domestic production settled at 30 cents a pound which prevailed until the present (October 1953) with custom smelters quoting 1 or 2 cents less. Chilean copper meanwhile advanced to 35½ cents a pound in Chile, about 36½ in the United States, but prices of other foreign copper approximated the domestic level.

TARIFF

When the market for copper collapsed at the end of the 1920's domestic producers had difficulty in disposing of their production and feared that they might even lose a large part of the domestic market. As a result of pressure at the time an excise tax of 4 cents a pound was imposed June 21, 1932. The Government became virtually the only importer in World War II and during the period it held this position the tax was not applicable. The tax was reinstated for a very brief period, following which it was suspended by acts of Congress from April 30, 1947, to June 30, 1950. The suspended tax, meanwhile, was reduced as a result of the trade-agreement negotiations at Geneva in 1947, to 2 cents a pound, effective March 16, 1949. The 2-cent tax came into effect finally on July 1, 1950. It was, however, suspended again on April 1, 1951, to February 15, 1953, or to the termination of the national emergency, whichever comes first, and the suspension was later extended to June 30, 1954. The law provides that the Tariff Commission must notify the President within 15 days after the end of any month in which the price drops below 24 cents a pound, delivered Connecticut Valley, and within 20 days thereafter the President must revoke the suspension.

Salient statistics of the copper industry, in the United States, in 1948–52

[In short tons]

	1948	1949	1950	1951	1952
Production:					
Primary-mine (recoverable)	834,813	752,750	909,343	928,330	925,377
Smelter:					
Domestic	842,477	757,931	911,352	930,774	927,365
Foreign	82,973	101,702	97,177	105,863	97,062
Total	925,450	859,633	1,008,529	1,036,637	1,024,427
Refinery:					
Domestic	860,022	695,015	920,748	951,559	923,192
Foreign	247,424	232,912	319,086	255,429	254,504
Total	1,107,446	927,927	1,239,834	1,206,988	1,177,696
Secondary copper recovered from old scrap only	505,464	383,548	485,211	458,124	414,635
Imports (unmanufactured) [1]	507,449	552,709	690,389	[2] 489,135	618,944
Refined	249,124	275,811	317,363	[2] 238,972	346,960
Exports of metallic copper [3]	207,022	195,960	192,339	166,274	[4] 212,390
Refined (ingots, bars)	142,598	137,827	144,561	135,305	174,135
Stocks at end of period:					
Refined	67,000	61,000	26,000	35,000	26,000
Blister, etc	183,000	261,000	232,000	182,000	185,000
Consumption:					
New refined (apparent consumption)	1,214,000	1,072,000	1,447,000	[2]1,304,000	1,360,000
Total refined (actual)	1,420,584	1,129,686	1,424,434	1,416,865	1,479,732
Price, average cents per pound	21.7	19.7	20.8	[5] 24.2	[5] 24.2

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering country under bond. Comprises copper in ingots, plates, and bars, ores and concentrates, regulus, blister, and scrap.
[2] Revised figure.
[3] Total exports of copper, exclusive of ore, concentrates, composition metal, and unrefined copper. Exclusive also of "Other manufactures of copper," for which quantity figures are not recorded.
[4] Due to changes in classifications data are not strictly comparable to earlier years.
[5] Exclusive of copper produced abroad and delivered in the United States.

Salient statistics of the copper industry, in the United States, January–July 1953

[In short tons]

	January	February	March	April	May	June	July
Production:							
Primary-mine (recoverable)	[1] 77,594	72,329	80,393	79,565	79,807	73,497	75,784
Smelter:							
Domestic	80,560	72,615	80,492	83,620	83,839	76,544	76,792
Foreign	5,607	6,329	9,254	9,904	10,529	9,039	6,870
Total	86,167	78,944	89,746	93,524	94,368	85,583	83,662
Refinery:							
Domestic	80,248	72,862	81,283	75,744	79,839	79,090	76,049
Foreign	21,691	22,571	26,073	29,138	31,075	35,553	34,346
Total	101,939	95,433	107,356	104,882	110,914	114,643	110,395
Secondary, recovered as refined by primary and secondary plants	16,325	14,632	21,013	21,384	21,424	19,009	15,748
Total imports (unmanufactured)	46,430	63,024	56,095	65,155	70,953	76,744	70,763
Imports of refined [2]	26,549	29,157	31,901	31,537	34,965	40,950	17,999
Exports of refined	6,570	4,402	6,957	5,082	6,583	5,615	10,192
Stocks at end of period:							
Refined	27,000	32,200	31,800	24,400	25,800	32,200	48,700
Blister, etc	187,000	186,000	184,000	196,000	207,000	203,000	208,000
Consumption:							
New refined (apparent consumption)	120,900	115,000	132,700	138,700	137,900	143,600	101,709
Total refined (actual) [3]	138,378	126,798	133,178	142,070	147,077	140,331	90,831
Price (cents per pound):							
Domestic, f. o. b. refinery [4]	24,200	24,968	29,289	29,902	29,683	29,688	29,687
Export, f. o. b. refinery [4]	34,780	34,783	34,451	32,863	29,710	29,699	29,482

[1] Revised figure.
[2] Data include copper imported for immediate consumption plus material entering country under bond.
[3] Includes estimate for chemical plants, foundries, and miscellaneous plants.
[4] As reported by E & MJ Metal and Mineral Markets. (After February 1953, price of Chilean copper excluded.)

Imports of copper into the United States, 1952 and January–July 1953

[In short tons]

	1952	1953						
		January	February	March	April	May	June	July
Canada	81,980	5,444	13,448	9,691	8,727	14,008	14,815	9,927
Chile	362,303	30,219	32,142	32,378	30,268	29,850	34,521	25,773
Cuba	19,934	64	1,412	2,793	1,535	1,529	2,385	1,342
Mexico	50,997	5,238	6,354	5,608	6,492	2,893	5,754	7,423
Other	15,019	253	1,573	975	1,380	3,540	2,723	2,819
Western Hemisphere	530,233	41,218	54,929	51,445	48,402	51,820	60,198	47,284
Yugoslavia	14,833	979	724	1,379	607	541	501	514
Philippines	14,787	143	2,833	121	69	2,974	75	2,299
Northern Rhodesia	28,225	.....	2,240	1,502	10,164	3,890	8,561	10,849
Other	30,866	4,090	3,298	1,648	5,913	11,728	7,409	99,817
Total	618,944	46,430	64,024	56,095	65,155	70,953	76,744	70,763

The following paragraphs summarize the major programs for production expansion:

The Copper Cities Mining Co., a wholly owned subsidiary of the Miami Copper Co., will bring into production the Copper Cities property, Globe-Miami district, Gila County, Ariz., probably in the latter part of 1954. The mill at the Castle Dome mine, also owned by Miami, will be moved to Copper Cities when the ore body of the former is exhausted and prior to the time the latter will be in production.

The American Smelting and Refining Co. will bring the Silver Bell unit, 40 miles northwest of Tucson, Ariz., into production in 1954. Estimated production will be 18,000 tons annually. Ore reserves are estimated at 32 million tons, assaying 0.9 percent copper, in 2 separate ore bodies, which can be mined by open-pit methods.

The Phelps Dodge Corp. is developing and equipping the Bisbee East (Lavender Pit) ore body, Warren (Bisbee) district, Arizona. Production at an expected annual rate of about 38,000 tons of copper should begin by the end of 1954 and continue for 11 or 12 years. The cost is estimated at $25 million.

The Wite Pine Copper Co., wholly owned subsidiary of the Copper Range Co., plans to bring the White Pine mine, Lake Superior district, Michigan, into production. Limited production is expected by mid-1954 and the annual target is 36,000 tons of copper. Reserves were estimated at 309,660,000 tons of ore averaging 21.3 pounds of copper per ton. Milling and smelting facilities are included in the plans for this project. A Government loan of $57,185,000 has been authorized for this property.

The Yerington mine, Lyon County, Nev., is being prepared for production by the Anaconda Copper Mining Co. The oxide ore body, containing an estimated reserve of 35 million tons averaging 0.97 percent copper, is to be mined by open-pit methods and the copper recovered by leaching. An estimated reserve of at least 15 million tons of sulfide ore of similar grade underlies the oxide ore body. Development and equipment of the property will require about $38 million. Production should begin by the end of 1953 and the maximum annual rate expected by 1955 is estimated at 33,000 tons of copper. Construction of integrated leaching-precipitation facilities is planned. Copper precipitates will be shipped for smelting.

The Kennecott Copper Corp. is preparing to mine by underground methods an undeveloped ore body near the company's open-pit operation at Ruth, Robinson (Ely) district, White Pine County, Nev. A very small margin of profit was expected based on the 1951 price-cost relationship.

The Greater Butte project of the Anaconda Copper Mining Co., Montana, announced in 1947, was designed to bring into production low-grade ore above the 3,400-foot level in the Butte Hill mines. It will cost about $27 million and make available more than 130 million tons of ore, averaging 1 percent copper, and will augment normal Butte production by 45,000 tons annually. Plant improvements to make this output possible include concentrator expansion, and a leach-precipitation-float plant for treating oxide ores.

The San Manuel Copper Corp., Pinal County, Ariz., wholly owned subsidiary of the Magma Copper Co., plans eventually to produce 70,000 tons of copper and 6 million pounds of molybdenum annually at its mine now under development. Reserves are more than 460 million tons, averaging 0.782 percent copper. Magma already has invested $10 million in this project and recently obtained a $94 million loan from the Reconstruction Finance Corp., part of a requested loan of $111,288,000, to develop and equip the property. The remainder of the funds required were to be obtained privately. A mill and smelter are included in the plans. Production is to begin in 1957.

CANADA

The program of the International Nickel to increase underground production to an eventual 13 million tons in order to offset declines from open-pit operations, approaching exhaustion, is making noteworthy progress and 10,200,000 tons of underground ore was produced in 1952. The goal of 13 million tons is equal to 85 percent of the total copper ore produced by underground methods in the United States in 1952. International Nickel Co. reserves were 256 million tons of ore containing 7,800,000 tons of nickel and copper.

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The Sherridon operation of Sherritt Gordon Mines, Ltd., Manitoba Province, Canada, was worked out in 1951 and the mining plants, concentrator, and employees' houses were being moved to the Lynn Lake operation where nickel and copper are to be produced. A new chemical metallurgical refinery, one of the first of its kind will be installed. Reserves are estimated at 14,100,000 tons averaging 1.223 percent nickel and 0.618 percent copper.

The Campbell Chibougamau Mines, Ltd., will develop its property on Merrill Island in Dore Lake, Quebec, and plans to start production in not less than 2½ years (presumably from mid-1952 when a purchase contract was entered into with the DMPA).

The Hudson Bay Mining & Smelting Co. has optioned a group of claims, said to be a "really good find" and to average 3.2 percent nickel, 2.2 percent copper, and 0.14 percent cobalt, in the Yukon Territory not far from the Alaskan border. Other claims in the area have been optioned to two other companies. The mountainous nature of the terrain and the relative remoteness of the area may impede development of producing properties there.

At the Gaspe property, Quebec, of Noranda Mines, Ltd., reserves of 67 million tons of 1.3 percent ore are already known; the property is being prepared for production.

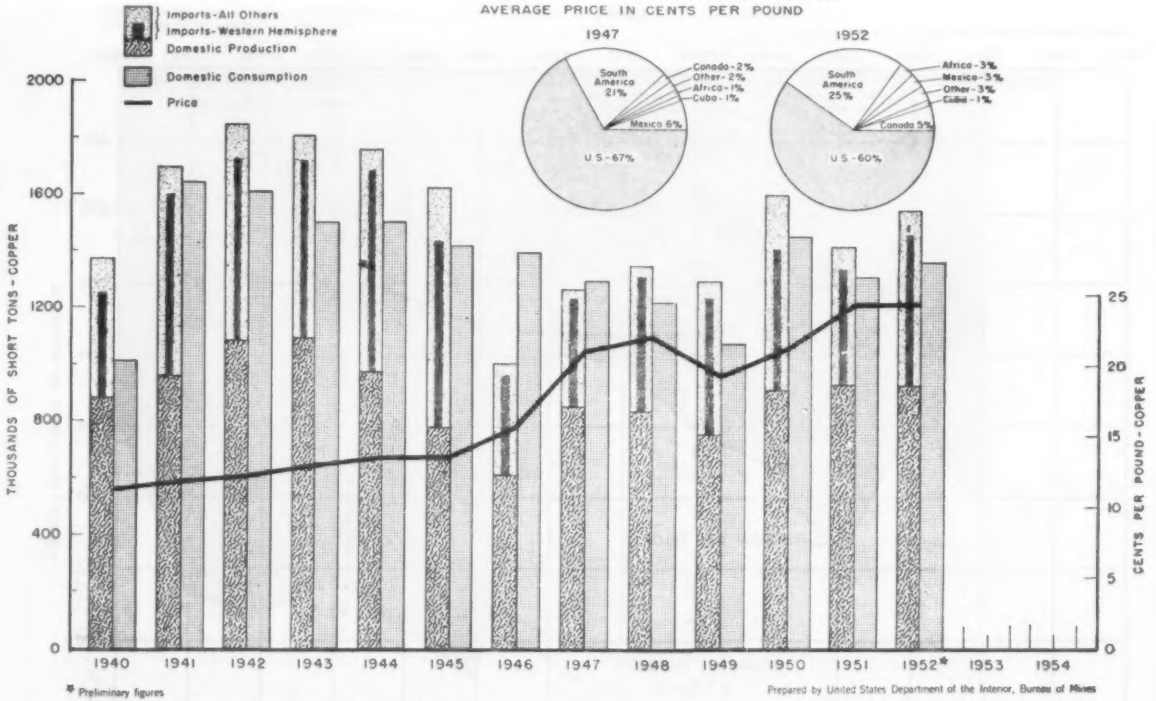
CHILE

At the Chuquicamata mine, Antofagasta Province, depletion of the oxide ore body, that has formed the basis of operations at this property since they began in 1915, caused the Anaconda Copper Mining Co. to construct a new metallurgical plant for treatment of the sulfide ores underlying the oxide ore body. The new plant (consisting of a sulfide concentrator and a smelter) should be in full operation in 1953. Output of new plant and existing plant should be in excess of 250,000 tons annually, compared with a range of 172,000 to 229,000 tons in 1948–52, inclusive.

PERU

The American Smelting & Refining Co. has carried on extensive drilling programs at the Toquepala and Quellaveco porphyry-type copper deposits, 20 miles apart, in southern Peru. Both deposits were found to contain substantial tonnages of ore susceptible to open-pit mining. Detailed investigations of providing power, water, railroad and port facilities, are required before determination is made as to placing either property on an operating basis. Ore reserves were given as in excess of 400 million tons, averaging slightly over 1 percent copper, and about 200 million tons averaging slightly less than 1 percent, respectively.

SUPPLIES AND CONSUMPTION OF COPPER
AVERAGE PRICE IN CENTS PER POUND



* Preliminary figures

Quoted price in 1942 thru 1947 includes weighted average bonus payments made to high cost domestic mines.

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Prepared by United States Department of the Interior, Bureau of Mines

Figure 1

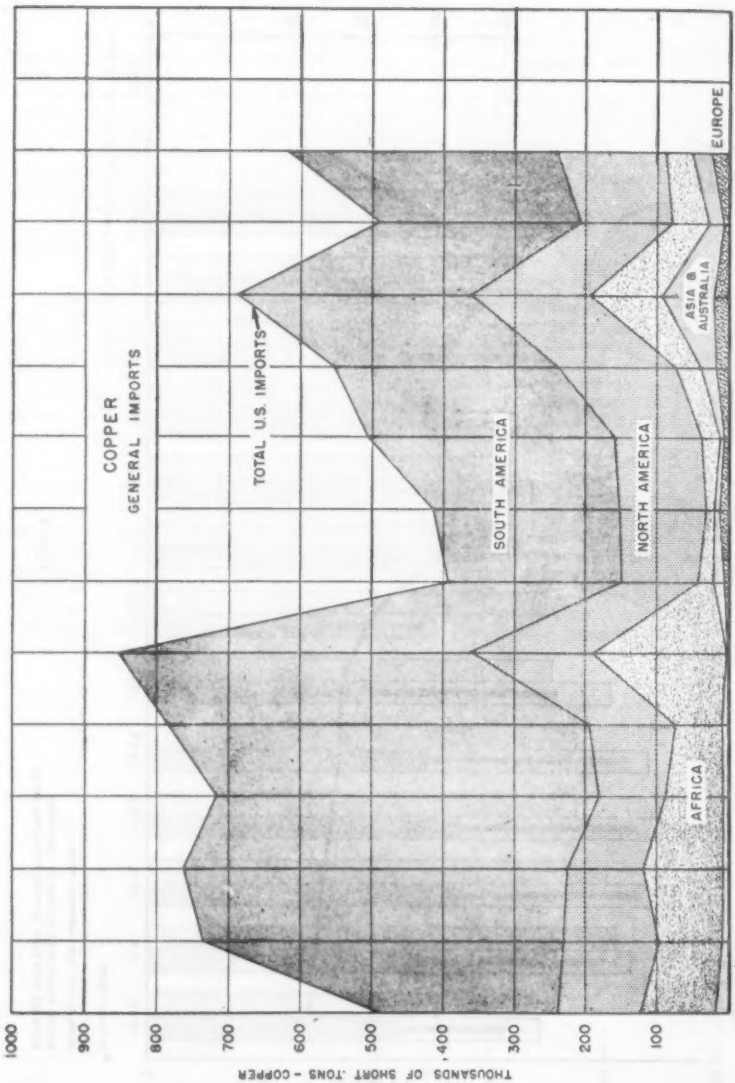

COPPER
GENERAL IMPORTS
TOTAL U.S. IMPORTS
SOUTH AMERICA
NORTH AMERICA
ASIA & AUSTRALIA
EUROPE
AFRICA
THOUSANDS OF SHORT TONS - COPPER
1000
900
800
700
600
500
400
300
200
100
1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

Figure 2

1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Prepared by United States Department of the Interior, Bureau of Mines

Figure 2

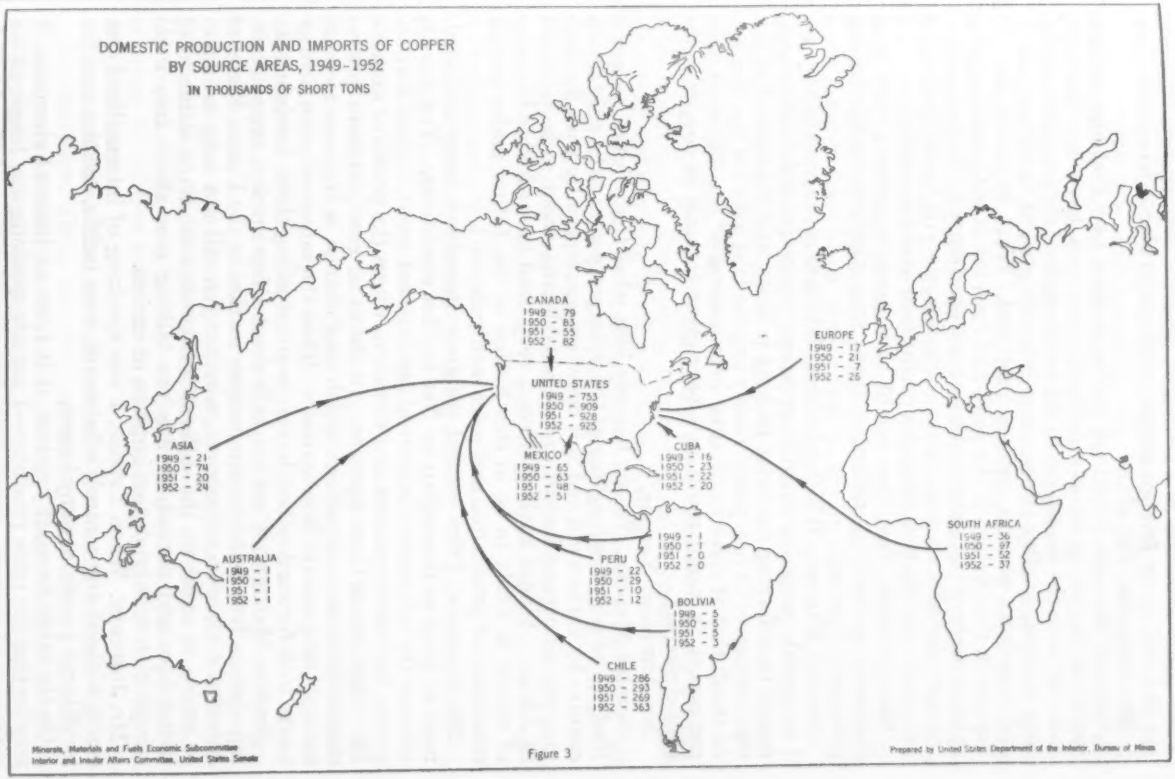


Figure 3

Senator MALONE. Copper domestic prices have ranged from 22½ to 30 cents over the last 3 or 4 years, 24½ cents being set by the Office of Price Administration as a ceiling on domestic copper, and 36½ cents set as a ceiling on foreign copper, with particular reference to Chile.

Mr. JOHNSON. Yes, sir.

Senator MALONE. I will ask you a question now that any engineer would be loathe to answer definitely, but you have been generally familiar with the variations in the production of copper domestically. New sources, smaller mines, come into being when the price goes up and close down when the price is controlled. What do you think might happen in this Nation if the price had been set at 36½ cents a pound in this country? If there had been some continuity to the price, allowing new deposits to come into production, do you think that might have had any effect on domestic production over the years?

Mr. JOHNSON. Yes; that would have brought about a very great increased production, assuming there was complete confidence that price would prevail.

Senator MALONE. Which of course there has never been in 21 years. I am merely assuming that Congress may some time get over its vagaries of transferring the price making policies, and the control of foreign commerce to just pretty nearly anyone that asks for it. But you do think that if some continuity were assured of the 36½-cent price per pound, it would result in a very great increase in copper in the United States?

Mr. JOHNSON. Yes, sir.

Senator MALONE. No one has any idea what the price of copper is likely to be with the juggling of the price per pound to be paid in this country by various old and new commissions, especially with the large amounts of copper known to be available and about to be produced in Africa. Would anybody have a very good idea of what the price of copper is likely to be in this Nation in the future under present conditions of production and price manipulation?

Mr. JOHNSON. Price control certainly introduces uncertainties almost as great as depending on free market conditions. You have in one case the influence of industrial development, technological developments, business expansion and recession, where the producer exercises his judgment on those matters. In the other case you have governmental decisions and policies which may change in response to international or domestic developments. Then the miner or manufacturer has to look forward as best he can to anticipating those developments.

Senator MALONE. When you talk about a free market, are you talking about a free domestic competitive market in the United States of America with some adjustment, whether you call it a duty or impost or excise, to make up the difference between that wage standard of living here and abroad, or are you talking now about free world competition with no duties, imposts, or excises.

Mr. JOHNSON. When I spoke, I was speaking of international free trade, without any controls whatsoever, even tariffs, because even the tariff is not a certainty any longer.

On the other hand, if you look at it from an internal viewpoint, it may be that the mine producer—I am not speaking any longer of the consumer of copper—would have less uncertainty with fixed tariffs if he can be sure that those tariffs will not be changing frequently.

Senator MALONE. Are you talking about an adjustable tariff which would always equalize the difference in the wage standard of living here and abroad?

Mr. JOHNSON. No; I had nothing specific in mind.

Senator MALONE. Just anything that the producer could depend on to equalize the domestic and foreign wage difference so that he would only be competing with people in the United States who pay the same wages and the same expense for materials?

Mr. JOHNSON. If there is to be a tariff, I think perhaps a fixed ad valorem tariff would be the simplest situation if he could count on it not changing.

Senator MALONE. You need something on which a producer can depend. A foreign producer pays very little for labor, pays no unemployment insurance or social security, and has very little responsibility to his working people, would through that method be put on an even basis with domestic producers. If the domestic producer could depend upon some system that took him out from under the fear of being put out of business through foreign sweatshop or low-cost production, then you think he would have a consistent future?

Mr. JOHNSON. Yes, sir. I do not know whether you want philosophy or not.

Senator MALONE. Yes.

Mr. JOHNSON. I am not sure that the miner wants entire relief from uncertainty. Perhaps he thinks that he is smarter than the other man and can outguess him on price changes.

Senator MALONE. He does not want relief from competition of people who are under the same price structure, is what you mean?

Mr. JOHNSON. That is right.

Senator MALONE. But if he is competing with people who are paying one-tenth the wages he has to pay, then he would welcome escape from that competition.

Mr. JOHNSON. Yes.

Senator MALONE. I think that completes it. What other metals do you have there?

LEAD

Mr. JOHNSON. Lead is another very important base metal. We have consumed that in the past 5 years in the amount of $330 million a year. Secondary lead furnishes us with three-eighths of the total supply. Of the primary lead supply, which amounts to about 800,000 tons a year a little more than half is obtained from foreign raw materials or imported as refined lead. Mexico, Canada, and South America furnish about three-quarters of the United States imports of lead. The first two alone have export surpluses greater than our imports. Western hemisphere lead reserves have been estimated at about 15 million tons, of which something like half are in the United States.

Senator MALONE. Let me ask you what you mean by reserves.

Mr. JOHNSON. Those are the reserves grouped by the Bureau of Mines as measured, indicated, and inferred. They would not be called known reserves by most engineers.

Senator MALONE. It does not take into account consistent development?

Mr. JOHNSON. It does not take into account the results of future mining and development work or any new discoveries; no, sir.

Senator MALONE. It is important for the very reason that for 21 years we have been fed this idea that we know where all our material is, therefore we must save that material and import it for our current use. As a matter of fact, the history of all metals—I make that flat statement—and fuels, indicates that there is more known reserves at the moment than there were when they first began to estimate when their reserves would finally be completely used up. I refer to the oil industry. The United States Geological Survey which I consider one of the outstanding contributors to our well-being in keeping track of all this information estimated in 1925 that about 5½ billion barrels of oil would be the limit of our known reserves. Today we have about 32 billion barrels of known reserves, and we have used untold quantities of oil.

As we have already brought out through testimony, we have more tungsten today than we had at the beginning of World War II, and we have used tremendous quantities of tungsten. It shows a bright future. If the price is such as to permit profit in mining and the production of any metals or fuel, we find reserves faster than we use them.

Mr. JOHNSON. I think the trouble is that most people feel that a reserve figure is an attempt to say how much there is now and forever afterward.

Senator MALONE. That is what I wanted to bring out. You do not mean that at all.

Mr. JOHNSON. No. If your investigation does something to dispel that idea, that alone would be worth the cost.

Senator MALONE. Let us revert to the copper business for just a moment. They used to say to me, where are there any copper deposits in the United States. If we use up the copper deposits that we know about, we are finished. We should save these deposits. I used to name several deposits and I could do that now. One of them I named was 100 miles from Reno, which is one of the greatest copper deposits in the United States. It could not be any good, they said, or we would be mining. I cannot remember the exact time; I was running the Walker River, when they were regulating the water down there with shovels and shotguns, and I had my hands full, but in the off season I had a branch engineering office and I patented 3 mining claims with a 3-finger jack. He did not have any money and I did not have much work. So I had him raise the fees to the Government for the patent, and I did the work, and finally I got paid for it. But they are included in the Anaconda claims now where there is one of the largest deposits in the country. They spent $35 or $40 million. On the tenth of this month I am helping to dedicate it. They are starting production.

There are many other deposits. I listed so many that it took several pages in one line listings. Not all of them are good, you understand, but if mining were a profitable enterprise in this country under some policy such as that you just outlined, there would be investigations going on continually by independent potential copper producers as well as the producers already in the business.

We have said many times it takes two or three hundred prospects to produce some metal. Out of 100 of these that produce metal, one

good mine results. There have been many men who spent their whole lives to do this job who have never made any money.

Mr. JOHNSON. Yes, sir.

Senator MALONE. I think you are contributing very valuable information to this committee. As you said, we should use this committee as a vehicle to bring to the attention of the public the fact that when you say reserves you do not mean that is all the metal there is in the United States or any other country; you mean that is all you know about at the moment.

Mr. JOHNSON. That is all you can count on at this moment.

Senator MALONE. But the facts are, are they not, that in all these metals you end up after a great war with more metal than you started out with because it becomes profitable to mine it. Is that not true? You heard the testimony yesterday that mercury mining was shut down and we have to get it from Spain. There is more mercury now than before World War II.

Mr. JOHNSON. Yes. That must not be carried too far. It is possible to deplete a given property by mining without doing exploration and development work.

Senator MALONE. That is right, and it is possible to find new property, and all history bears that out on mining.

Mr. JOHNSON. I believe it does.

Senator MALONE. I hate to revert to one Secretary of the Interior we had for 15 or 16 years who himself never understood that simple philosophy and wrote articles for magazines that when we mined the amount of mineral we knew we had at that time we would complete the mining of that metal in this Nation.

Mr. JOHNSON. It seems contradictory. It is not actually. If I may submit this statement for the lead situation with the charts?

Senator MALONE. The text on the lead will be accepted and the charts 1, 2, and 3, showing the supplies and consumption of lead, the source of lead imports into this Nation, and the source in figures on the map, domestic production and imports of lead from all nations. It will be accepted as a part of Mr. Johnson's testimony and will appear at this point in the record.

(The information is as follows:)

LEAD

Lead, the softest and the heaviest of the base metals, is vital to modern civilization, particularly in the fields of transportation, communications, and chemical manufacture.

Transportation in the United States annually requires over a billion pounds of lead for storage batteries, cable coverings, and tetraethyl gasoline, while equally important but lesser quantities are used in the field of communications, in type metal, telephone and telegraph cable coverings, solder, and the glass of electronic tubes. The impenetrability of lead to short-wave-length radiation will bring about increased use of lead as atomic energy is further exploited, for not only does lead serve to prevent penetration of neutron and gamma rays, but it remains uncontaminated and can be used indefinitely without becoming radioactive.

The United States is not self-sufficient in lead. During the 27-year period, 1925–51, 48 percent of domestic requirements were met from current domestic mine production, 33 percent from secondary sources, and 19 percent from imports, or, stated in another way, these imports were equal to 28 percent of the primary lead consumed. Imports of lead have exceeded exports in all years since 1925 except in the depression years 1933, 1934, 1936, and in 1939. Dependency on foreign lead increased sharply beginning in 1940 and for the period 1940 through 1952, the total lead content of lead imported for consumptive uses and stockpiling exceeded exports by approximately 4,500,000 short tons, or an average of 345,000

tons annually. In 1952 imports of lead in all forms totaled 628,000 tons. Although the imports of 628,000 tons in 1952 are high in relationship to the 1,131,000 tons of consumption (660,000 tons of which is primary metal) and domestic mine production of 390,000 tons, it must be remembered that Government, as well as consumers, smelters, and refiners all increased their stocks during the year.

Of the 4,596,000 tons of lead imported in 1940-52, Canada supplied 20 percent, Mexico 41 percent, and South America 16 percent to give a total of 3,543,000 tons or 77 percent from the Western Hemisphere. The Eastern Hemisphere, principally Australia, with 13 percent, provided the remainder.

At the present time domestic mine production of lead has declined to a rate (June–July–August 1953) of 325,000 tons per year and it is estimated the total mine production will be about 345,000 tons or approximately half the production rate of 1925 and 1926, about 78 percent of the annual 1941–45 output, and about 88 percent of the annual rate in 1946–52.

Domestic ore reserves of lead and their distribution are such that American industry could produce at the rate of about 400,000 tons per annum, given a moderate improvement in the present price cost ratio.

In the period, 1948–52, requirements of primary or new lead in the United States were annually about 652,000 tons, and during the same period average domestic mine production was 402,000 tons. Thus under conditions such as prevailed in 1948–52, we required about 250,000 tons of lead imports to meet use requirements plus such additional imports as were bought to add to private and Government stocks. Under conditions that exist in 1953 when domestic mine production is expected to be 345,000 tons, we need imports of about 380,000 tons to supply primary lead requirements, assuming secondary lead production will continue at its present somewhat reduced level.

The annual production of Canada and Mexico for 1948–52 averaged 415,000 tons, while their average consumption for the same group of years was, respectively, 57,000 and 10,000 tons which leaves a total of 352,000 net tons available for export. South American production for the same years averaged 126,000 tons and requirements were about 58,000 tons leaving a net surplus of 68,000 tons available for export.

Currently known ore reserves in the Western Hemisphere will yield almost 15 million tons of lead. As with zinc, it is believed the potential for additional discoveries is very good.

TABLE 1.—*Salient statistics of the lead industry in the United States, 1948–52 and 1943–47 (average)*

[In short tons]

	1943–47 (average)	1948	1949	1950	1951	1952
Production of refined primary lead:						
From domestic ores and base bullion	366,388	339,413	404,449	418,809	342,644	383,358
From foreign ores and base bullion	65,045	67,281	72,889	89,505	75,049	89,494
Total	431,433	406,694	477,338	508,314	417,693	472,852
Recovery of secondary lead	388,261	500,071	412,183	482,275	518,110	471,294
Imports (general):						
Lead in pigs, bars, and old	198,895	276,013	289,889	461,827	[2] 188,175	523,659
Lead in base bullion	1,271	7,186	2,373	3,488	2,281	389
Lead in ores and matte	65,712	63,907	107,279	76,520	[2] 67,471	104,515
Exports of refined pig lead	4,211	411	969	2,795	1,281	1,762
Consumption of primary and secondary lead	1,082,344	1,133,895	957,674	1,237,981	1,184,796	1,130,795
Prices:						
New York:						
Average per period cents per pound	8.46	18.04	15.36	13.30	17.49	16.47
Quotation at end of period...do	9.41	21.50	12.00	17.00	19.00	14.12
London: Average for period...do	7.57	17.16	16.95	13.29	20.25	17.09
Mine production of recoverable lead [1]	396,140	390,476	409,908	430,827	388,164	390,161
World smelter production of lead	1,385,800	[2] 1,364,000	[2] 1,505,000	[2] 1,644,000	[2] 1,604,000	1,796,000

[1] Includes Alaska.
[2] Revised figure.

Salient statistics of the lead industry in the United States, 1952 monthly average and 1953, by month

[In short tons]

	1952 monthly average	1953								
		January	February	March	April	May	June	July	August	September
Production of refined primary lead	39,405	44,363	41,901	42,576	41,702	36,692	27,632	35,338	------	------
Recovery of secondary lead	39,274	37,931	32,922	34,007	36,529	32,005	36,082	------	------	------
Imports (general):										
Lead in pigs, bars, and old	43,588	46,550	40,430	33,834	42,612	46,971	44,272	29,535	------	------
Lead in base bullion	32	41	126	246	123	269	------	------	------	------
Lead in ores and matte	8,700	13,090	8,604	14,369	8,272	10,460	14,683	16,983	------	------
Total	52,330	59,681	49,160	48,449	51,007	57,700	58,955	46,518	------	------
Exports	147	28	26	70	28	134	19	(1)	------	------
Consumption of primary and secondary lead	94,236	94,366	90,093	101,123	102,852	99,159	106,754	97,715	------	------
Prices:										
New York:										
Average per month cents per pound	16.467	14.192	13.500	13.404	12.683	12.750	13.413	13.683	14.00	13.74
London: pound per long ton [2] do	(1)	(1)	(1)	(1)	82.219	82.166	88.690	93.152	95.363	93.344
Mine production of recoverable lead	32,514	30,660	29,458	30,715	31,137	29,051	28,472	26,531	------	------
Refiners stocks end of month (Dec. 31)	31,305	41,087	48,173	50,786	58,259	53,015	42,157	46,713	------	------
Consumers stocks	80,515	83,670	84,690	84,321	82,532	90,752	95,305	90,984	------	------

[1] Not available.

[2] Average of daily mean of bid and ask quotations, per long ton, at morning session London Metal Exchange.

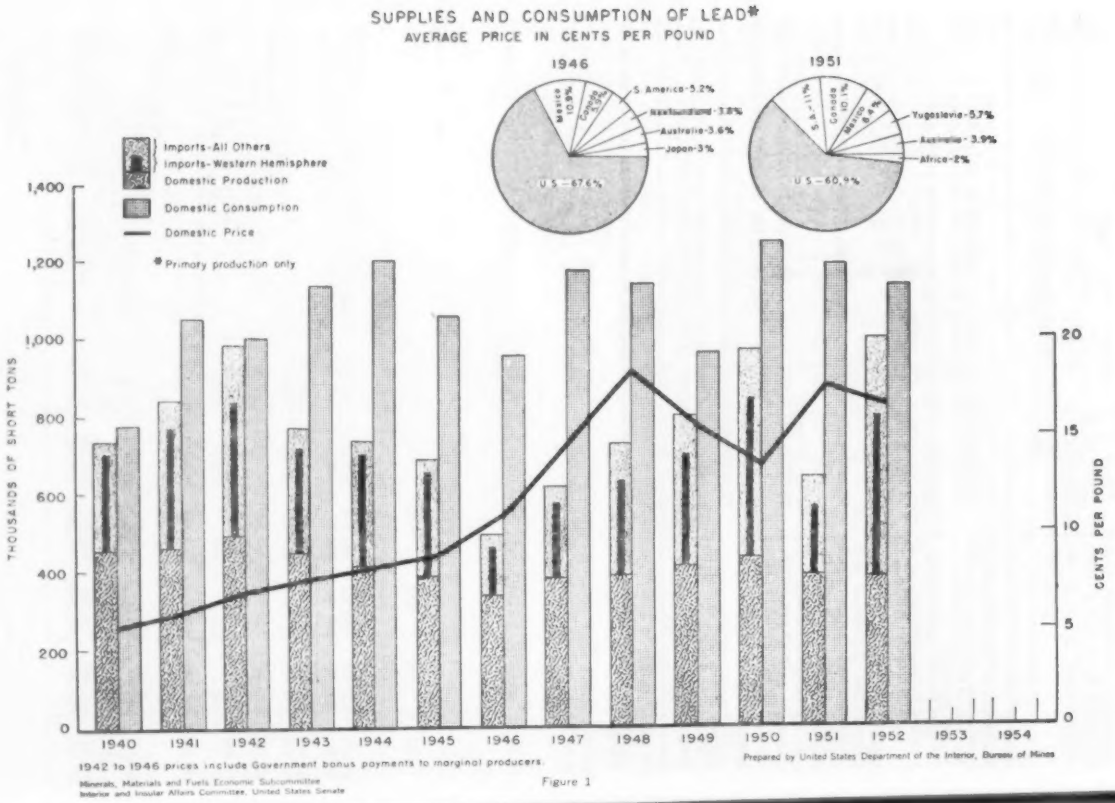
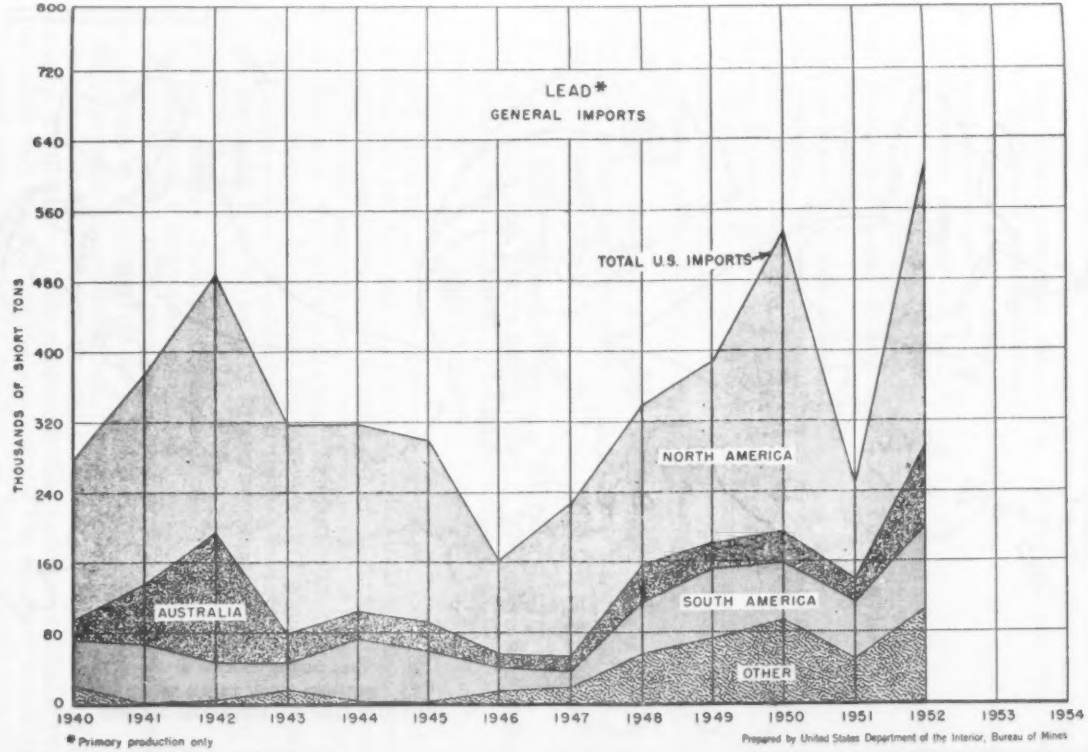

SUPPLIES AND CONSUMPTION OF LEAD*
AVERAGE PRICE IN CENTS PER POUND
1946
1951
Mexico 10.8%
Canada 3.2%
S. America-5.2%
Newfoundland-3.8%
Australia-3.6%
Japan-3%
U.S.-67.6%
Mexico 11%
Canada 10.1%
Yugoslavia-5.7%
Australia-3.9%
Africa-2%
U.S.-60.9%
Imports-All Others
Imports-Western Hemisphere
Domestic Production
Domestic Consumption
Domestic Price
*Primary production only
THOUSANDS OF SHORT TONS
CENTS PER POUND
1,400
1,200
1,000
800
600
400
200
0
20
15
10
5
0
1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954
1942 to 1946 prices include Government bonus payments to marginal producers.
Prepared by United States Department of the Interior, Bureau of Mines
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 1

800

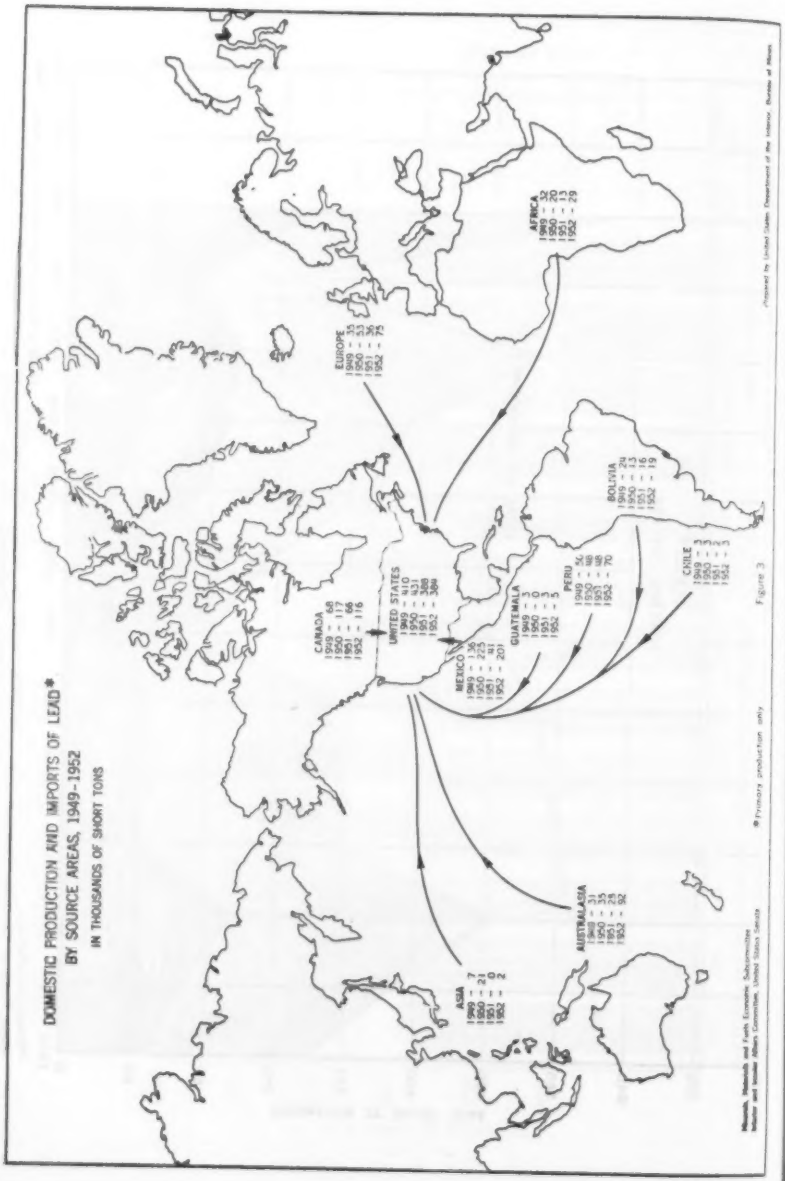
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 1



Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2


DOMESTIC PRODUCTION AND IMPORTS OF LEAD*
BY SOURCE AREAS, 1949-1952
IN THOUSANDS OF SHORT TONS
EUROPE
1949 - 35
1950 - 33
1951 - 36
1952 - 35
AFRICA
1949 - 32
1950 - 20
1951 - 13
1952 - 29
CANADA
1949 - 68
1950 - 87
1951 - 68
1952 - 116
UNITED STATES
1949 - 410
1950 - 431
1951 - 388
1952 - 384
MEXICO
1949 - 136
1950 - 225
1951 - 211
1952 - 201
GUATEMALA
1949 - 3
1950 - 10
1951 - 5
1952
PERU
1949 - 56
1950 - 68
1951 - 48
1952 - 70
BOLIVIA
1949 - 29
1950 - 13
1951 - 16
1952 - 19
CHILE
1949 - 3
1950 - 3
1951 - 3
1952
AUSTRALASIA
1949 - 33
1950 - 35
1951 - 28
1952 - 32
ASIA
1949 - 27
1950 - 21
1951 - 20
1952 - 2
Prepared by United States Department of the Interior, Bureau of Mines
*Primary production only
Figure 3

MERCURY

Mr. JOHNSON. Mercury is another of the base metals consumed in this country, in the amount of $6 million a year, chiefly used in electrical apparatus, industrial and control instruments, the manufacture of chlorine and caustic soda, and agricultural poisons, such as fungicides, insecticides, pesticides, and so on. In wartime mercury uses are very likely to be greatly increased.

Senator MALONE. Does it mean that when the price is higher there is increased production?

Mr. JOHNSON. Yes, sir.

Senator MALONE. Is not the history of mercury, and all other metals, that when the price provides a profit the production increases?

Mr. JOHNSON. No, sir. I think at the present time there is a fair price for mercury.

Senator MALONE. A fair domestic price?

Mr. JOHNSON. Yes, sir. I think there is not sufficient confidence that price can be maintained.

Senator MALONE. Let me correct my first statement. If some policy is laid down by the Congress of the United States in accordance with the Constitution of the United States so that there is some principle under which a profitable price is established, then production would be increased?

Mr. JOHNSON. Mercury is a rather special case. Spain and Italy are able to produce mercury so much more cheaply that they are able to put the mercury mines in the rest of the world out of production if they choose.

Senator MALONE. What are the wages in Spain and Italy?

Mr. JOHNSON. I do not know. I heard it testified yesterday that they are incredibly low, probably a few cents a day.

Senator MALONE. I think it was testified yesterday $11 a month.

Mr. JOHNSON. Yes, sir.

Senator MALONE. And our producers pay wages about one and a half times that per day, and in addition to industrial insurance, unemployment insurance, and social security, which in themselves amount to more than the wages in some foreign countries; is that not true?

Mr. JOHNSON. Yes, sir; I heard that testimony.

Senator MALONE. If we could pay wages of $11 a month, do you think foreign producers would be able to undersell our producers?

Mr. JOHNSON. I would not like to venture what would happen if we paid $11 a month wages.

Senator MALONE. I am talking about production.

Mr. JOHNSON. I understand you.

Senator MALONE. If we were doing the same work for $11 a month, do you think we could keep up our production?

Mr. JOHNSON. No; certainly not.

Senator MALONE. It is not understood in very many places in the country, I will say. All the statements that each nation should produce what they can produce the cheapest and the consumer would get the benefit were discredited by testimony of the last several days that the consumer never gets the benefit because foreign producers take

what the traffic will bear. You say you hate to contemplate what would happen in this country if we announced tomorrow we were going to pay Spanish or Italian wages in this country. Even if you could get away with it, which you could not do, you would wreck the economic and social structure which we have built up in the past 175 years. Do you agree with that statetment?

Mr. JOHNSON. Yes, sir.

Senator MALONE. Go ahead.

Mr. JOHNSON. That is all I wish to say about mercury, Senator, if I may submit a statement for the record.

Senator MALONE. It will be accepted as a part of your testimony, together with charts 1, 2, and 3, showing supplies and consumption of mercury produced in the United States and Western Hemisphere, imported from the Western Hemisphere and the consumption, and chart 2 is the sources of mercury imported into the United States. Chart 3 shows the source of all foreign nations for 1949, 1950, 1951, and 1952. This chart shall be attached to the text and submitted as a part of your testimony at this point in the record.

(The information is as follows:)

MERCURY

The United States usually depends on foreign sources for a major part of its requirements for mercury. In only 7 years since 1909 have domestic mines contributed enough metal to fill United States demand, and in 3 of them (1940, 1941, and 1942) successive all-time peak annual prices were established. In 1952 the United States produced 12,500 flasks (of 76 pounds each) or 29 percent of total consumption. United States reserves of ore containing 5 pounds or more of mercury per ton are estimated at 46 times United States production in 1952.

Canada produces no mercury but imported from 2,000 to 10,000 flasks annually in 1948–52, doubtless a guide to consumption there. Mexico, on the other hand, produced from 5,000 to 9,000 flasks annually in 1948–52, most of which was exported. North American reserves of ore containing in excess of 5 pounds of mercury are estimated at 40 times North American production of 21,000 flasks in 1952.

In other Western Hemisphere countries there is very little production; in recent years the most important has been a byproduct of gold mining in Chile. This group of countries consumes more than it produces but precise data are not available. It is estimated that Western Hemisphere reserves of ore containing 5 pounds or more of mercury per ton approximate 41 times Western Hemisphere production in 1952.

The current world situation is one of production in excess of consumption. World production capacity exceeds consumption by an even wider margin.

United States deposits of mercury are scattered widely in the Western States but most of them are located in California, Nevada, Oregon, Idaho, Texas, and Arizona. The United States does not produce enough mercury to meet its requirements except in periods of unusually high demand and prices. The average mercury content of ores treated in 1952 was 0.35 percent, whereas those treated in Spain and Italy, which supplied 63 percent of the world production in 1952, ranged from over 1 percent up to and possibly exceeding 6 percent.

Principal mercury-producing properties in the United States in 1952 were the Mount Diablo, Contra Costa County; Abbott, Lake County; Juniper and New Idria (including San Carlos), San Benito County; Guadalupe, Santa Clara County; Culver-Baer, Mount Jackson (including Great Eastern), and Buckman, Sonoma County, Calif.; Hermes, Valley County, Idaho; Cordero, Humboldt County, Nev., and Bonanza, Douglas County, Oreg.

In most deposits in the United States the ore bodies tend to be small and highly irregular. The mode of occurrence is such that reserves are seldom

blocked out much in advance of mining. Consequently, attempts to calculate the reserves are more hazardous than is the case with metals such as copper, lead, and zinc, reserves of which usually are blocked out well ahead of mining operations.

Salient statistics of the mercury industry in the United States, 1943–47 and 1948–52 (average)

[In flasks of 76 pounds]

	1943–47 (average)	1948	1949	1950	1951	1952
Production	33,794	14,388	9,930	4,535	7,293	12,547
Number of producing mines	81	20	23	16	47	39
Average price per flask, New York	$126.09	$76.49	$79.46	$81.26	$210.13	$199.10
Imports:						
General	34,491	41,732	96,918	60,564	44,926	68,686
For consumption	32,577	31,951	103,141	56,080	47,860	71,855
Exports	793	526	577	447	241	400
Consumption	45,392	46,253	39,857	49,215	56,848	42,556

Salient statistics of mercury in 1952 and January–June 1953, by quarters

[In flasks of 76 pounds]

Period	Production [1]	General imports	Exports	Consumption
1952:				
January–March	3,050	13,309	185	10,100
April–June	3,000	16,337	98	9,500
July–September	3,320	10,919	69	13,200
October–December	3,130	28,121	48	10,200
Total	[2] 12,547	68,686	400	[2] 42,556
1953:				
January–March	3,530	24,265	38	12,700
April–June	3,790	6,431	72	13,200

Period	Stocks at end of period [3]		Price per flask at New York (average)
	Consumers and dealers [4]	Producers [5]	
1952:			
January–March	28,300	866	$205.12
April–June	30,400	1,107	199.54
July–September	28,400	1,122	189.16
October–December	33,700	685	202.57
Total			199.10
1953:			
January–March	39,200	626	205.39
April–June	38,100	1,592	194.27

[1] In addition at least 600 flasks were produced from the treatment of scrap such as old batteries in the first quarter of 1952, 685 in the second, 550 in the third, 665 in the fourth quarter, 675 in the first quarter of 1953, and 800 in the second quarter.
[2] Final annual figures; quarterly data not adjusted.
[3] Excludes metal held in strategic stockpile.
[4] Largely excludes redistilled metal.
[5] Held by reporting companies.

The deficiency of United States production in relation to consumption is made up usually by imports from Spain, Italy, and Mexico, with Yugoslavia supplying noteworthy quantities in more recent years. Thirty-eight percent of imports in 1952 came from Italy, 35 from Spain, 15 from Yugoslavia, and 12 from Mexico.

General imports of mercury into the United States, 1952 and January–July 1953

[In flasks of 76 pounds]

	1952	1953						
		January	February	March	April	May	June	July
Canada	20	28				28		
Mexico	7,971	1,450	627	777	1,106	1,227	1,136	1,521
Other								
Western Hemisphere	7,991	1,478	627	777	1,106	1,255	1,136	1,521
Italy	26,026	4,061	1,098	2,105	426	553	200	349
Spain	24,333	7,306	2,889	2,222	424	150	50	
Yugoslavia	10,186	851	444	357	704	427		1,001
Other	150			50				
Total	68,686	13,696	5,058	5,511	2,660	2,385	1,386	2,871

Canada is not now producing mercury but two relatively large producing mines were developed in World War II, one of which is at Pinchi Lake, Omineca mining district, about 40 miles north of Vanderhoff station on the Canadian Pacific Railway. The deposit is characterized by large cinnabar-bearing areas in veins and impregnations mainly in dolomitized and brecciated limestone along zones of fracturing and shearing. The grade of the ore treated in World War II was about 0.3 percent mercury. The other deposit is located on Silver Creek east of Takla Lake, and also in the Omineca district. The grade of the ore was low and the deposit was brought to the production stage through United States Government assistance. High prices and demand are believed needed to reinstate Canada as an important producer of mercury. Canada's mercury requirements are filled largely outside of the Western Hemisphere.

Mexico regularly produces several thousand flasks of mercury from a number of deposits scattered over a wide area. There are six major districts containing mercury deposits: Huitzuco (State of Guerrero), Huahuaxtla (Guerrero), Nuevo Mercurio (Zacatecas), Cuarenta (Durango) Sain Alto (Zacatecas), and Canoas (Zacatecas). The deposits can be divided broadly into two major geologic classes: (1) Deposits in rhyolitic volcanic rocks, and (2) deposits in other rocks, mostly sedimentary. According to the Geological Survey the deposits in rhyolite are most numerous, but they are comparatively small. The deposits in sedimentary rocks though few in number include most of the large mines. Relatively high prices are needed to bring out large-scale production of mercury in Mexico.

SUPPLIES AND CONSUMPTION OF MERCURY
AVERAGE PRICE PER FLASK (76 POUNDS)

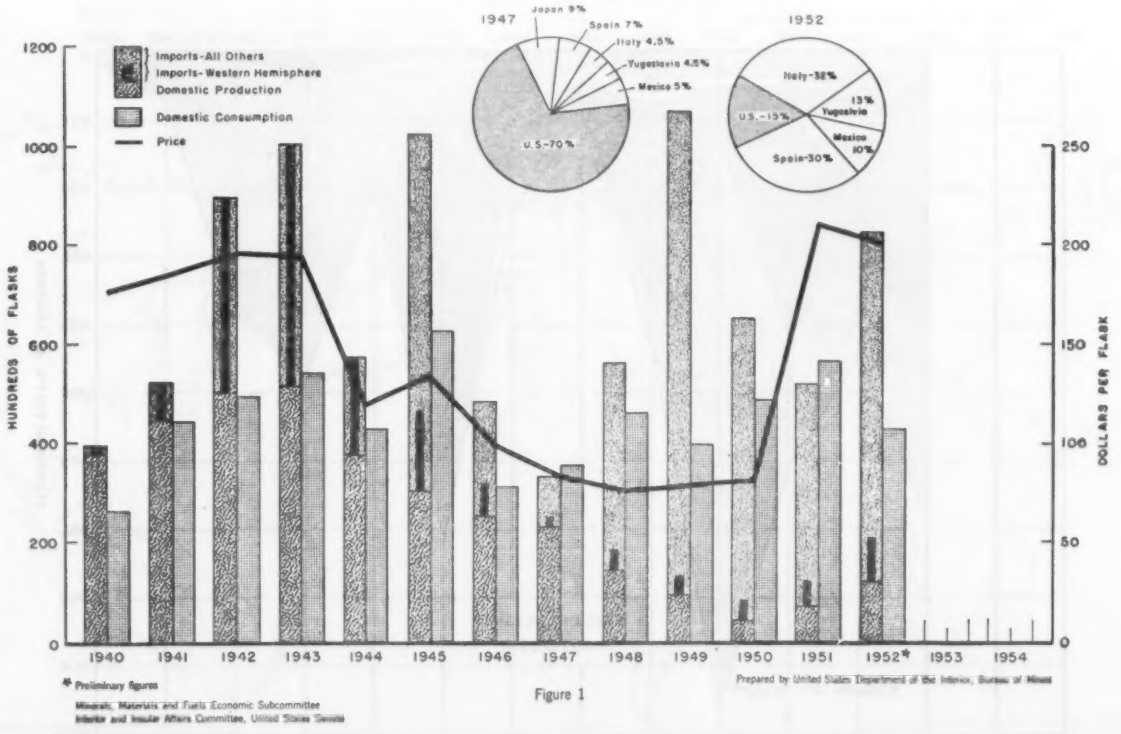
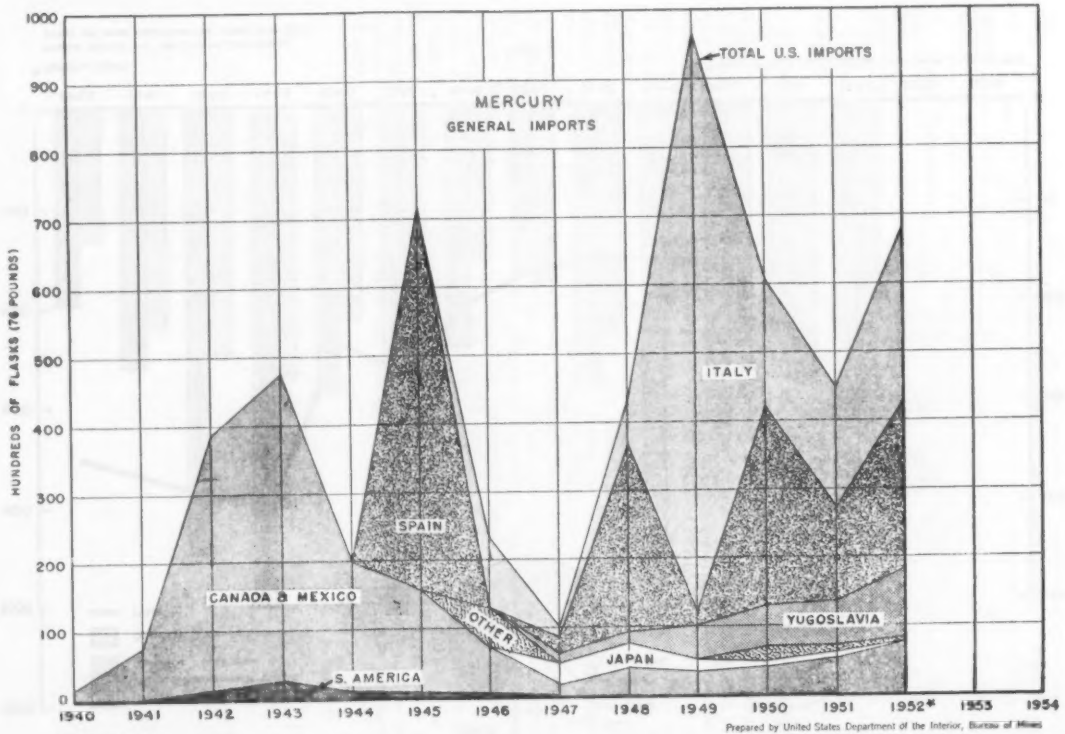


Figure 1



* Preliminary figures

Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2

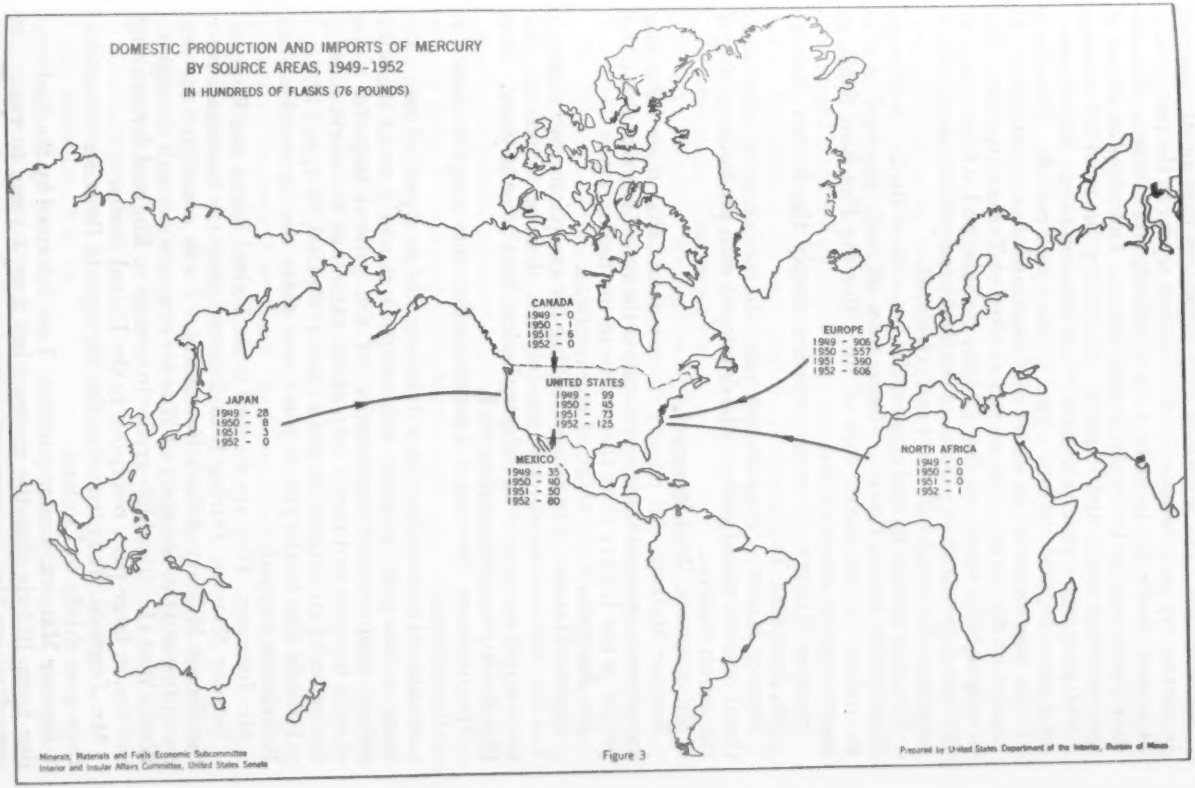

DOMESTIC PRODUCTION AND IMPORTS OF MERCURY
BY SOURCE AREAS, 1949-1952
IN HUNDREDS OF FLASKS (76 POUNDS)
CANADA
1949 - 0
1950 - 1
1951 - 6
1952 - 0
EUROPE
1949 - 906
1950 - 557
1951 - 390
1952 - 606
UNITED STATES
1949 - 99
1950 - 145
1951 - 73
1952 - 125
JAPAN
1949 - 28
1950 - 8
1951 - 3
1952 - 0
MEXICO
1949 - 35
1950 - 40
1951 - 50
1952 - 80
NORTH AFRICA
1949 - 0
1950 - 0
1951 - 0
1952 - 1
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

Figure 3

TIN

Mr. JOHNSON. Tin is another very important base metal consumed in the country in the amount of $170 million a year in the past 5 years. It is used chiefly for tinplate, solder, babbitt, and bronzes. We produce practically no tin in the United States. Our supplies consist of the secondary metal and imports. Secondary tin recovery averages 30,000 long tons a year or a third of our consumption. Imports averaged about 90,000 long tons a year in the 5-year period. Two-thirds of this was imported as metal and one-third as concentrates to be smelted at the Government-owned smelter at Texas City, Tex. The principal fields are in southeast Asia, Bolivia, and Africa. Asia in 1952 produced about 64 percent of the total mine production of 173,000 long tons; Bolivia, 18 percent; and Africa, 14.

The only sizable proved commercial reserves of tin in the Western Hemisphere are in Bolivia. These were officially reported in 1940 to contain 500,000 metric tons of tin. For the Far East fields, no reserve figures are available.

Senator MALONE. Your reserves are simply the known reserves.

Mr. JOHNSON. Yes, sir.

Senator MALONE. They do not take into consideration what additional reserves would probably be developed with profitable mining of the known reserves.

Mr. JOHNSON. That is correct.

Senator MALONE. All mining history shows that there have been more known reserves of various metals at the end of any certain mining period in our history than there were in the beginning.

Mr. JOHNSON. I can think of no exceptions.

Senator MALONE. I have been looking for exceptions ever since you had Mr. Ickes as Secretary of the Interior. I never found one. But he certainly set the mining industry back at least 25 or 50 years. Does that finish your statement on tin?

Mr. JOHNSON. Yes, sir; if I may submit a more complete statement on the subject.

Senator MALONE. The text will be accepted as a part of your testimony at this point together with charts 1, 2, and 3, as of the other metals, supplies and consumption of tin, general imports, source of such imports, and then a map of the nations of the world showing the source of all imports for the 4 years 1949, 1950, 1951, and 1952.

I would like to ask you if you know where the tin supplies from Bolivia are shipped.

Mr. JOHNSON. They are shipped to the United States and England.

Senator MALONE. During 1943, I investigated the tin situation for the Senate Military Affairs Committee. I was consultant for that committee and the Secretary of War for strategic minerals throughout World War II. The high-grade tin ores go to England for smelting and are, in large part, reshipped to the United States.

Mr. JOHNSON. It is true that the high-grade Bolivian tin concentrate goes chiefly to England.

Senator MALONE. Under contract. I am informed by the Ambassador from Bolivia that the contract has 2 or 3 years to run. The secondary ore that is very expensive to smelt comes to the Texas smelter. That was included in my report in 1943.

Mr. JOHNSON. The Texas smelter was built especially to treat Bolivian ore, and it is the only smelter at this time that is capable of treating those less desirable Bolivian ores.

Senator MALONE. Less desirable ores is a good phrase, and that is what we receive from Bolivia. But the most desirable ores are shipped across the ocean for smelting and a greater part of the metal is shipped back here. It crosses the ocean twice. This committee has been charged with the responsibility of determining how to increase the availability of these materials to the United States in wartime. Would it be better to ship more of the tin across the ocean to be smelted and returned across the ocean during wartime, or would it be better to get some of the high-grade ores for our own smelting operations?

Mr. JOHNSON. If that traffic were interrupted, sir, the Bolivian ores could all come to the Texas smelter. I think it has sufficient capacity to take them all in times of emergency. That was the purpose of it being built, the anticipation of the possible destruction of all smelting facilities in Europe.

Senator MALONE. You are of great comfort to this committee. There is more commonsense in that statement than we generally receive.

Mr. JOHNSON. I do not want to create any misunderstanding. Bolivia could not furnish all of our requirements.

Senator MALONE. Not all the present requirements?

Mr. JOHNSON. That is right.

Senator MALONE. We require 60,000 tons a year?

Mr. JOHNSON. That is correct.

Senator MALONE. And they can produce somewhere between 40,000 and 45,000 tons?

Mr. JOHNSON. I do not think it is that much. I believe their present rate of production is down below 25,000. They have produced in excess of 30,000, however, and presumably could again.

Senator MALONE. I did not want to give the impression that is their present production, but they have produced more than 30,000 tons in the past. Of course, before we finish our hearings we will have the experts from Bolivia and other South American nations before the committee to testify on the materials they produce. I am informed that 40,000 tons per year would not be impossible, if proper arrangements were made. That does not seem unreasonable to you, does it?

Mr. JOHNSON. It is not impossible.

Senator MALONE. Over a period of 2 or 3 years.

Mr. JOHNSON. I do not know that you could do it in 2 or 3 years.

Senator MALONE. Five years. But you must have some objective. Do you think it might be increased?

Mr. JOHNSON. It might be possible.

Senator MALONE. That will be developed later. But the present situation is that the best-grade ores go to England to be smelted, and then we purchase a large amount of that tin for our own consumption.

Mr. JOHNSON. Yes, sir.

Senator MALONE. And the secondary ore comes to Texas.

Mr. JOHNSON. Yes, sir.

Senator MALONE. And there is what you might call a tin cartel, an understanding between the smelting operations in England and the Malayan States production, which is controlled by the English smelters, so that the price of tin can be manipulated.

Mr. JOHNSON. I would not want to say that, Senator. I do not know of any cartel.

Senator MALONE. Call it whatever you like. It is under one particular operation.

Mr. JOHNSON. I do not think at the present time there is any combination of interests that can control the price of tin. That is the point I want to make.

Senator MALONE. We are such a large purchaser we have something to do with the price?

Mr. JOHNSON. That is part of the reason. The consumers have a lot to say about it.

Senator MALONE. What is the world production of tin?

Mr. JOHNSON. I think it is of the order of 170,000 long tons.

Senator MALONE. We are the largest single purchaser?

Mr. JOHNSON. Yes, sir.

Senator MALONE. But you have never heard of any manipulation of the price of tin or rubber?

Mr. JOHNSON. Yes. I thought you were speaking of the present time. There have been tin cartels.

Senator MALONE. Has the situation changed in the past years as far as control of the operation is concerned?

Mr. JOHNSON. I believe they have, since the beginning of the war.

Senator MALONE. Due to the increase in domestic tin consumption and the fact we are the largest purchaser of tin, do you think we can have some effect on the market?

Mr. JOHNSON. I do not know the full reason for the abandonment of the cartel, but it was disbanded.

Senator MALONE. Maybe it was not needed during the war due to the great demand.

Mr. JOHNSON. That is one reason for it, undoubtedly.

Senator MALONE. It could be resumed at any time under the same control.

Mr. JOHNSON. Yes, sir, I think it could be.

Senator MALONE. That is right.

Mr. JOHNSON. You are speaking of an agreement between producing nations.

Senator MALONE. As long as the contract is made between England and Bolivia, and they receive the valuable ores from Bolivia and control the production in the Malayan States, which are the two greatest sources——

Mr. JOHNSON. You would have to include others; for example, Belgian Congo and Indonesia.

Senator MALONE. That has never been any chore when the United States is the purchaser.

Mr. JOHNSON. I think there would be considerable hesitation in those countries to attempt a producers' cartel if it was felt that the United States was definitely opposed.

Senator MALONE. You are aware that there is a conference going on in Geneva now which is discussing how this very material should be

handled to get a maximum price? This conference is not going to let any information out until they see what Congress is going to do.

Mr. JOHNSON. No, sir; I did not know there were any tin discussions under way at the present time.

Senator MALONE. There are. I suppose in some way we can get the information before Congress convenes. I hope so. This Geneva conference is taking up many items, but the participants are complaining about the uncertainty as to whether Congress is going to permit further United States participation in the discussions and whether Congress will continue to allow the International Materials Conference to control the supply and give nations their entitlements for consumption. That is the way the world consumption of many metals is divided. The International Materials Conference was substituted for the International Trade Organization when the latter fell on its face in committee. These hearings and the unrest in Congress has interrupted the program. If Congress goes along with it, it will be resumed, of course.

Mr. JOHNSON. If you wish to go on with that subject, Senator, I think Mr. Zinner would like to have his assistant, Mr. Merrill, who is here, and who has had special responsibilities in connection with tin.

Senator MALONE. We will take that up later. I should not have gone as far as I have, because we are delaying your testimony. It is another matter we intend to take up later in hearings with the representatives of foreign nations. Does that complete your statement on tin?

Mr. JOHNSON. Yes, sir.

Senator MALONE. Do you have a text?

Mr. JOHNSON. We turned that in already.

Senator MALONE. The charts already described, and the text, will be accepted, and appear in the record at this point as a part of Mr. Johnson's testimony.

(The information is as follows:)

TIN

The Western Hemisphere, which accounts for nearly half the world consumption of primary tin, is deficient in reserves and now produces less than a fifth of the total world supply. The United States itself produces only negligible quantities and its known deposits are small and uneconomic. Bolivian tin deposits, the source of practically the whole Western Hemisphere output, are numerous and sizable, but production there is costly compared with Malaya and Indonesia.

USES, SUBSTITUTES, AND CONSERVATION

Tin is one of the most useful of the base metals because of its fusibility, malleability, resistance to corrosion, readiness to alloy with many other metals, and attractive silvery white color. Tin is but little affected by air at ordinary temperature even in the presence of moisture and has excellent resistance to organic acids, consequently its major use has been in the form of tin plate for canning and packaging foods. Tin flows readily under pressure and may easily be rolled into foil or extruded into tubes. In combination with other metals it imparts valuable properties to numerous alloys of major industrial importance, such as bronzes, solders, and babbitts.

The following tables present both monthly and annual salient statistics of tin:

TABLE 1.—*Salient statistics of tin in the United States, 1948–52*

[In long tons]

	1948	1949	1950	1951	1952
Production:					
Mine	4.7	68.4	94.1	88.0	98.7
Smelter [1]	36,700	35,800	33,100	31,900	22,800
Secondary	26,900	22,200	31,700	30,700	28,800
Imports for consumption:					
Metal	49,200	60,200	82,800	28,300	80,500
Ore (content)	37,500	38,300	26,000	29,600	26,500
Total	86,700	98,500	108,800	57,900	107,000
Exports of metal	90	150	800	1,500	400
Average price per pound at New York [2] cents	99.25	99.32	95.56	128.31	120.44
Consumption:					
Primary	59,900	47,200	71,200	56,900	45,300
Secondary	30,900	25,200	33,300	31,300	28,000
Total	90,800	72,400	104,500	88,200	73,300
World mine production	154,000	161,800	169,600	169,900	173,200

[1] Includes tin content of ores used direct to make alloys.
[2] American Metal Market.

TABLE 2.—*Salient statistics of tin in the United States, July–December 1952 and January–June 1953*

[In long tons]

	1952						6-month total
	July	August	September	October	November	December	
Production:							
Smelter [2]		50	2,500	3,400	4,000	3,700	13,650
Secondary	1,900	2,100	2,200	2,600	2,300	2,500	13,600
Imports for consumption:							
Metal	6,600	8,500	7,600	6,900	5,900	7,200	42,700
Ore (content)	5,500	2,400	1,100	4,900	2,200	3,300	19,400
Total	12,100	10,900	8,700	11,800	8,100	10,500	62,100
Exports of metal	3	17	4	20	139	23	206
Average price per pound, New York	$1.215	$1.21	$1.21	$1.21	$1.21	$1.215	
Consumption:							
Primary	1,700	4,200	4,200	4,700	4,300	4,500	23,600
Secondary	1,900	2,100	2,200	2,600	2,300	2,500	13,600
Total	3,600	6,300	6,400	7,300	6,600	7,000	37,200

	1953						6-month total [1]
	January	February	March	April	May	June	
Production:							
Smelter [2]	4,000	3,400	3,900	3,800	3,100	3,000	21,200
Secondary	2,400	2,300	2,400	2,300	2,200	2,300	13,900
Imports for consumption:							
Metal	7,700	5,300	6,700	7,200	6,700	5,500	39,100
Ore (content)	3,900	4,100	4,600	1,900	2,000	4,200	20,700
Total	11,600	9,400	11,300	9,100	8,700	9,700	59,800
Exports of metal	1	6	3	22	7	46	85
Average price per pound, New York	$1.215	$1.21	$1.21	$1.01	$0.97	$0.93	
Consumption:							
Primary	4,800	4,400	5,200	5,200	5,000	5,000	29,600
Secondary	2,400	2,300	2,400	2,300	2,200	2,300	13,900
Total	7,200	6,700	7,600	7,500	7,200	7,300	43,500

[1] Figures are preliminary, subject to revision.
[2] Texas City smelter.

The most important single use for tin is the making of tinplate. Solder and bronze are the next most important uses. Collapsible tubes and foil account for small requirements. Various tin-bearing chemicals are commercially important. Table 3 shows consumption of tin by uses.

Except for the precious metals, gold and silver, tin has been the highest priced of the common metals for some years. As a consequence much research has been carried on to find substitutes, but for most of the established uses of tin the search for satisfactory substitutes has met with little success. Aluminum has been used as a substitute for making foil and collapsible tubes.

The most important tin-saving development has been the introduction of electrolytic tinplate in place of hot-dipped tinplate. The former can be made with much less tin and for many purposes is equally serviceable. Solders have been developed with a low tin content. When necessary, consumption of tin can be drastically reduced by restriction of nonessential uses and other conservational measures.

TABLE 3.—*United States tin consumption, in long tons by end-use products, 1948–52*

	1948			1949			1950		
	Secondary	Primary	Total	Secondary	Primary	Total	Secondary	Primary	Total
Tin plate [2]	------	31,500	31,500	------	29,600	29,600	------	35,400	35,400
Solder	6,100	15,000	21,100	7,200	8,100	15,300	9,100	18,300	27,400
Babbitt	3,500	3,500	7,000	2,500	2,000	4,500	2,900	3,500	6,400
Bronze	17,700	4,000	21,700	12,100	2,400	14,500	16,400	4,200	20,600
Tinning	200	2,300	2,500	200	1,900	2,100	200	2,800	3,000
Collapsible tubes and foil	100	800	900	100	800	900	200	1,400	1,600
Other manufactures	3,300	2,800	6,100	3,100	2,400	5,500	4,500	5,600	10,100
Total	30,900	59,900	90,800	25,200	47,200	72,400	33,300	71,200	104,500

	1951			1952 [1]			5-year total			
	Secondary	Primary	Total	Secondary	Primary	Total	Secondary	Primary	Total tin consumed	Percent of total tin consumed
Tin plate [2]	------	30,500	30,500	------	[1]27,300	[1]27,300	------	154,300	154,300	36
Solder	6,700	13,000	19,700	7,500	7,700	15,200	36,600	62,100	98,700	23
Babbitt	3,400	2,500	5,900	2,300	2,000	4,300	14,600	13,500	28,100	7
Bronze	16,900	4,800	21,700	14,800	3,600	18,400	77,900	19,000	96,900	22
Tinning	300	2,400	2,700	200	2,100	2,300	1,100	11,500	12,600	3
Collapsible tubes and foil	200	800	1,000	100	600	700	700	4,400	5,100	1
Other manufactures	3,800	2,900	6,700	3,100	2,000	5,100	17,800	15,700	33,500	8
Total	31,300	56,900	88,200	28,000	45,300	73,300	148,700	280,500	429,200	100

[1] Excludes terneplate.
[2] Excludes 5,200 long tons of tin contained in imported tin-base alloys, of which 2,700 tons were used for solder; 2,000 tons for bronze and brass; 360 tons for babbitt; and 150 tons for other products.
[3] Includes small tonnage of secondary pig tin and tin acquired in chemicals.

PRODUCTION

Tin is mined chiefly from placer deposits in which cassiterite (tin oxide) is the valuable tin mineral, and to a lesser extent, as in Bolivia, from lode deposits in which cassiterite is also the chief tin mineral. The chief tin fields are in southeast Asia, Bolivia, and Africa. The leading producers of southeast Asia are Malaya, Indonesia, Siam, Burma, China, and Indochina. In Africa, Belgian Congo and Nigeria lead. The following table shows world production in 1952:

Area	Long tons	Percent of total world tin production
Africa	23,500	14
Western Hemisphere	33,000	19
Asia	112,000	64
Europe	3,000	2
Australia	1,500	1
Total world	173,000	100

The known deposits in the United States are either too small or too low grade to afford a significant national resource. These domestic occurrences have been exhaustively studied and numerous unsuccessful attempts have been made to exploit certain of them. The Government is at the present time giving financial assistance in a tin-mining venture at Lost River, Alaska.

In 1952, 100 long tons of tin were produced domestically compared with 90 tons in 1951. Alaska was the principal producer. Operations in Alaska were confined mainly to placer deposits of the Northern Tin Co., Inc., on Buck Creek and lode mining by the United States Tin Corp., at Lost River on Seward Peninsula. At Climax, Colo., the Climax Molybdenum Corp. produced some tin as a byproduct of molybdenum mining and at Kings Mountain, N. C., the Foote Mineral Co. recovered small tonnages of tin as a byproduct of mining spodumene ores.

SECONDARY TIN

Secondary tin is reclaimed from tinplate and other scrap. The annual yield has been equal to about one-third of the domestic-tin consumption. About a third of this secondary tin is derived from reworking industrial scrap resulting from fabrication of primary tin metal, and two-thirds is recovered from worn out and discarded articles. Of the total secondary tin about 10 percent is recovered as metallic tin—mostly by detinning plants treating clean tinplate clippings. The remainder has been in the form of alloys (87 percent) and chemicals (3 percent). A good portion of the use of tin is dissipative and does not add to the reservoir of metal in use that could be drawn upon should imports cease. More than 85 percent of the tin used for making tinplate is not recovered, and substantial tonnages consumed for tinning and chemicals are for purposes not amenable to recovery. The recovery of tin from old cans has been tried, but largely due to the collection and cleaning problem it has not proved economical. During 1948–53, the secondary tin recovered in the United States averaged 28,000 long tons annually.

RESERVES

Western Hemisphere

The principal reserves of the Western Hemisphere are in Bolivia. In 1940, estimates by the Bolivian Department of Mines gave Bolivia 500,000 metric tons of contained tin in ore (positive and probable).

Alaska.—According to Materials Survey—Tin (1953) the total reserves of all classes of tin ore in Alaska are estimated to contain 5,000 tons of metallic tin. Further exploration may add substantially to this figure.

Canada and United States.—Cassiterite has been found in many States of the United States, but these occurrences are of minor economic importance.

Eastern Hemisphere

The chief tin reserves of the Eastern Hemisphere lie in a mineralized belt which is continuous through lower Burma, Thailand, the Malay States, into the islands of Singkep, Banka, and Billiton in Indonesia. No recent and authoritative estimates of these reserves have been made, but they are believed to be on the order of 3 to 5 million tons, and largely in the form of placer deposits.

WORLD CONSUMPTION

World consumption of primary tin in 1952 (excludes U. S. S. R.) totaled 129,000 long tons, a decrease of 7 percent compared with 1951, and about 42,000 tons less than the tin mined in 1952. A geographical breakdown of tin consumption in 1952 is presented in the following table:

Area	Long tons	Percent of total world primary tin consumption
Africa	3,000	2
Western Hemisphere	53,500	42
Asia	9,000	4
Europe	61,000	47
Oceania	3,000	2
Total world	129,500	100

PRICES

The price of tin is quoted in many markets, but the principal quotations are those in New York in cents per pound and in London in pounds sterling per long ton. Both the Commodity Exchange, Inc., New York, and the London Metal Exchange permit trading in tin for immediate and future delivery. The following table presents tin prices in New York, annually from 1948 to 1952:

Straits tin prices in New York, American metal market, grade A

	Average (cents per pound)		*Average (cents per pound)*
1948	99.25	1951	128.31
1949	99.32	1952	120.44
1950	95.56		

Early in April 1953, world tin prices broke from $1.215 cents a pound to a low of $0.78 on July 27. Since August 1 the price has ranged from 80 to 84 cents a pound.

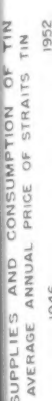
TARIFF

Tin, both in the form of metal and ore, is admitted free of duty by the Tariff Act of 1930, paragraph 1785, but with the proviso that, in case the mines of the United States are producing 1,500 tons annually, a tariff of 4 cents a pound on ore, and 6 cents a pound on metal shall be imposed and notice given by proclamation of the President.

FOREIGN TRADE

Tin has been one of the principal imports of the United States and ranked eighth in value among all commodities in 1952. The value of tin imports in 1952 totaled almost $300 million, and was the highest recorded. Imports of metallic tin, 94 percent tin alloy, and concentrates were the main items in foreign trade of the United States in tin in 1952. The principal source of metal has been Malaya, and of tin concentrates, Bolivia. Bolivia was the source of 51 percent of concentrates imported from 1948 through 1952 for treatment by the Texas City smelter which began to produce in 1942.

Exports of metallic tin are not large, averaging about 600 long tons annually mostly to Western Hemisphere destinations.



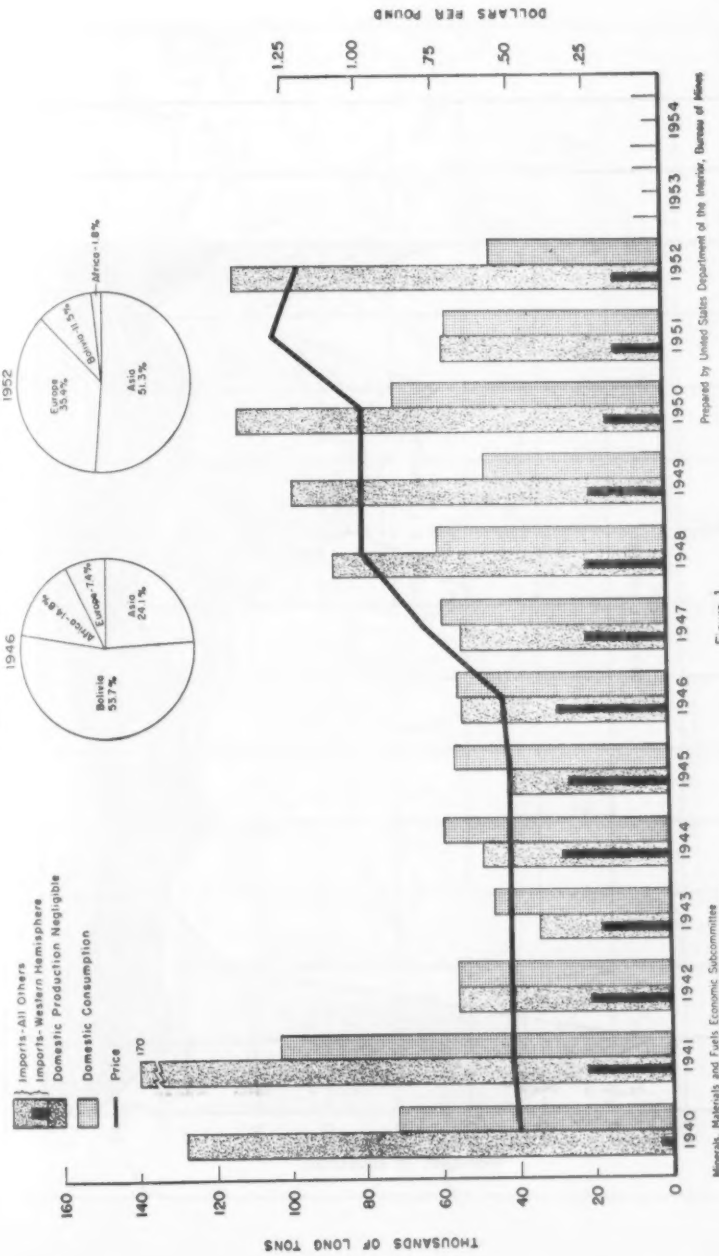

SUPPLIES AND CONSUMPTION OF TIN
AVERAGE ANNUAL PRICE OF STRAITS TIN
Imports-All Others
Imports-Western Hemisphere
Domestic Production Negligible
Domestic Consumption
Price
170
THOUSANDS OF LONG TONS
DOLLARS PER POUND
1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954
1946
Bolivia 53.7%
Asia 24.1%
Europe 7.4%
Africa-14.8%
1952
Europe 35.4%
Asia 51.3%
Oceania 11.5%
Africa-1.8%
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

Figure 1

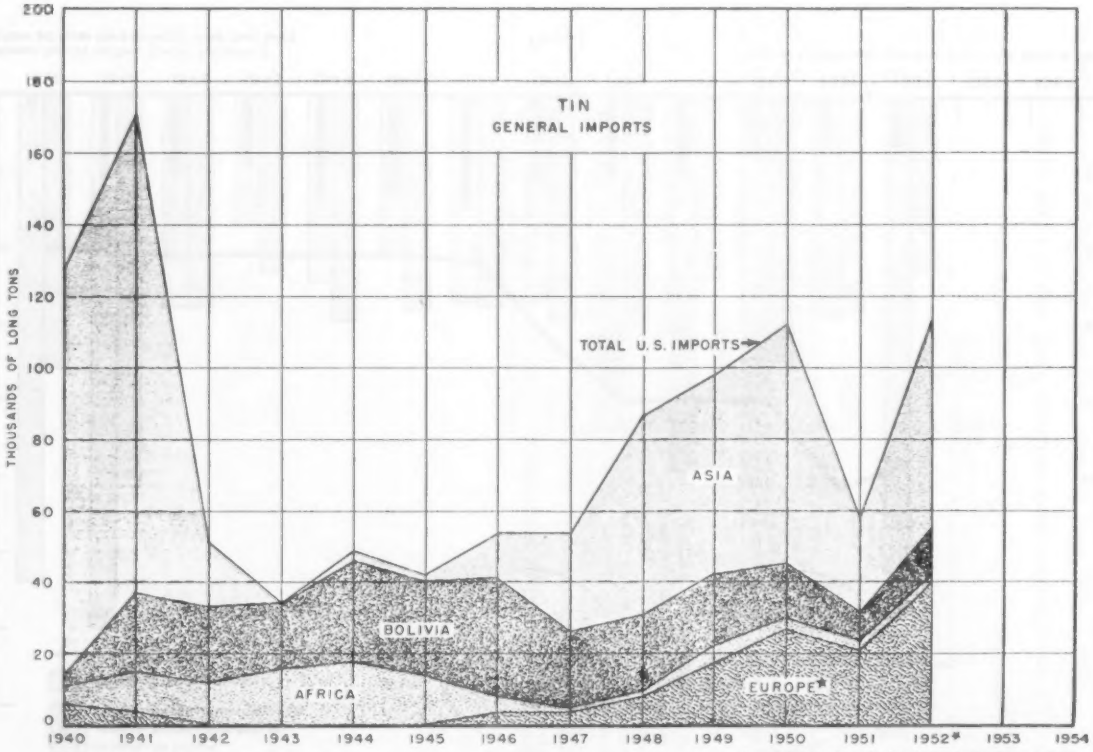

TIN
GENERAL IMPORTS
THOUSANDS OF LONG TONS
200
180
160
140
120
100
80
60
40
20
0
TOTAL U.S. IMPORTS
ASIA
BOLIVIA
AFRICA
EUROPE*
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952*
1953
1954
* Includes 1,000 tons from Australasia in 1940.
Prepared by United States Department of the Interior, Bureau of Mines
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2

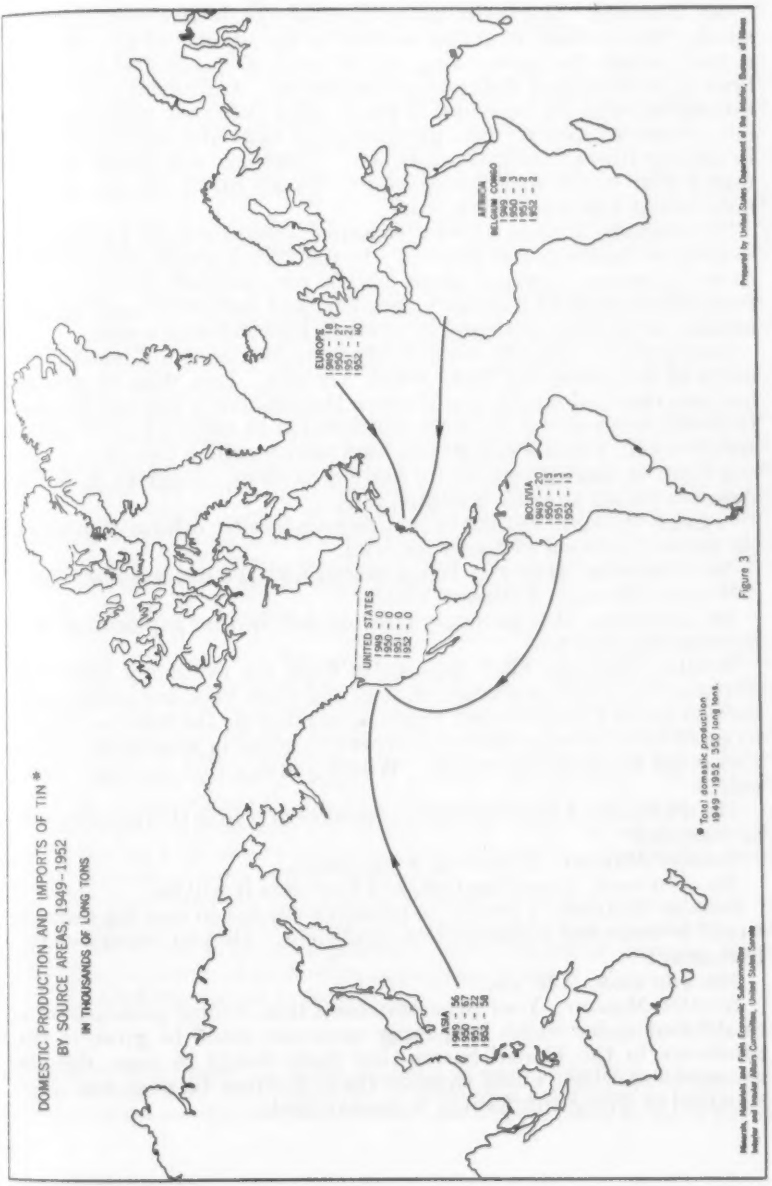

DOMESTIC PRODUCTION AND IMPORTS OF TIN *
BY SOURCE AREAS, 1949-1952
IN THOUSANDS OF LONG TONS
EUROPE
1949 -- 18
1950 -- 27
1951 -- 27
1952 -- 90
AFRICA
BELGIAN CONGO
1949 -- 3
1950 -- 3
1951 -- 3
1952 -- 2
UNITED STATES
1949 -- 0
1950 -- 0
1951 -- 0
1952 -- 0
BOLIVIA
1949 -- 20
1950 -- 13
1951 -- 13
1952 -- 13
ASIA
1949 -- 56
1950 -- 57
1951 -- 218
1952 -- 58
* Total domestic production
1949-1952: 350 long tons.
Figure 3
Prepared by United States Department of the Interior, Bureau of Mines
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2

ZINC

Mr. JOHNSON. Zinc is the last of the base metals of which I wish to speak. We consume it in this country in the amount of $250 million a year, chiefly for galvanizing, which takes 40 percent of the total, brass 25 percent, and die castings 20 percent. Additional substantial tonnages of zinc are consumed in forms other than slab, including zinc ores converted directly into pigments, and salts and zinc scrap used in making alloys, chemicals, and so on. These uses add almost 400,000 tons a year to the total consumption. In all forms we use about a million and a quarter tons a year.

This supply is made up of 3 elements: domestic mine production, secondary recovery, and imports. In the 5-year period 1948 to 1952 these 3 elements averaged about 640,000 tons domestic mine production, 300,000 tons of secondary recovery, and 380,000 tons of import, making an average total supply of about 1,300,000 tons a year.

Zinc imports normally come chiefly from Mexico and Canada, with much of the remainder from South America. Less than 10 percent has been obtained outside the Western Hemisphere in the past 5 years. Domestic zinc reserves are large, estimated at 16 million tons of recoverable metal. Canada and Mexico have some 8 million tons of reserves, and likewise good prospects for adding to them. Reserves in South America are set at about 5 million tons.

Senator MALONE. It may be that there is meager information about the mineral reserves of South America.

Mr. JOHNSON. That may be the reason why she has less reserves.

Senator MALONE. I suggest that.

Mr. JOHNSON. It is perfectly possible that further exploration will increase her reserves.

Senator MALONE. Then apparently from the testimony yesterday of one of the chief producers of zinc, and from your testimony, production in the United States, which would include the reserves, would no doubt be increased if there was some continuity in price under which zinc could be profitably mined. Would you say that is a fair statement?

Mr. JOHNSON. I am sure that the reserves of zinc in this country will be extended.

Senator MALONE. If mining is continued.

Mr. JOHNSON. Assuming that, and I am sure it will be.

Senator MALONE. Yesterday a producer was not so sure the reserves would be extended under present conditions. Do you remember the testimony?

Mr. JOHNSON. Yes, sir.

Senator MALONE. Your prior statement that if some principle were established under which long-range assurance could be given to the producers in the United States that there would be some definite arrangement which would equalize the differences between our wage standard of living and foreign wage standards.

Mr. JOHNSON. And competition between metals likewise.

Senator MALONE. Both the reserves and the production would be materially increased in this country, in your opinion?

Mr. JOHNSON. Yes, sir.

Senator MALONE. Of course, you are the one who should say this if it is true, because you are living every day with metal production. One of the things we overlook, is it not, when we discuss self-sufficiency, is our laboratory work and discoveries? Someone is liable at any time to make a technological discovery which will upset calculations.

Mr. JOHNSON. Yes. The unsatisfactory thing about technological development, if you consider it unsatisfactory, is that it does not give you a permanent advantage. Your competitors very soon have the advantage of it also.

Senator MALONE. Could you not make a statement of this kind: Practically any industrialist who abandons his research work for a 5-year period can just about count himself out of business?

Mr. JOHNSON. Yes. I did not mean to imply that he could sit on the other fellow's coattails.

Senator MALONE. We have a new metal now that you have discovered. We are going to Los Angeles on the 3d and 4th to hear testimony from producers of military and commercial airplanes as to what they could and would do if we could manufacture all of this new metal we need. Your Bureau of Mines laboratory on titanium has made a great contribution in the development of a process for the production of titanium. Of course, the process has not been completely perfected. You are familiar with the work going on there?

Mr. JOHNSON. Yes, sir.

Senator MALONE. The testimony in Henderson when your experts and the producers of Titanium Corporation of America testified, showed that the corporation is producing less than 4 tons per day. They have a 10-ton-per-day contract. Only 2 producers in the United States are producing about 2,500 tons a year. It was testified by the head of the Wright-Patterson Air Base in Dayton, Ohio, that 100,000 to 150,000 tons a year is needed if it would be available. We intend to find out more about the need for titanium from the actual producers. This metal is a substitute for several metals under certain conditions. Personally, I think you agree with me that it is a wonderful thing that laboratory work can be continued.

The charts and the text will be accepted at this point as a part of your testimony, and the charts are the supplies and consumption of zinc, No. 1; No. 2, the zinc general imports, source of imports; chart No. 3 is the source of all foreign imports for 4 years.

(The information is as follows:)

ZINC

Zinc is vitally important to the industrial strength of the United States both in peace and war. This importance is based upon galvanizing by which zinc preserves and prolongs the life of iron and steel products; upon its use in making

brass, and upon its use in die castings whereby intricate, close tolerance castings such as parts for tools, electrical appliances, hydraulic systems, fuel pumps, etc., can be produced cheaply and in volume. Zinc is in every plane, automobile, truck, tractor, and ship, as well as in cartridges, control mechanisms, and communications systems, whether military or civilian.

Until 1934, the United States was self-sufficient in zinc, but since that date has been dependent upon imports for quantities ranging from 14,000 tons of recoverable zinc in 1934 to 519,000 tons in the peak war year 1943. In 1952 imports in terms of recoverable zinc (85 percent of the content of ores and concentrates plus 100 percent of slab zinc) were 497,000 tons and through the first 7 months of 1953 had already reached 288,000 tons in ores and concentrates and 181,000 tons as slab zinc or an indicated rate of 732,000 tons of recoverable zinc from imports for the year.

During the war years 1941–45 imports exceeded exports by an average of 325,000 tons annually. Since the war (1946–52) imports have exceeded exports by an average of 339,000 tons and 1952 and 1953 have progressively been years of greater importations as noted above.

Although the United States in the period 1940–52 imported 5,330,000 tons of zinc it should be noted that 92 percent of that quantity was derived from neighboring countries in the Western Hemisphere, with 42 percent coming from Mexico, 35 percent from Canada, and 15 percent from Central and South America.

The United States could increase domestic production of zinc since measured, indicated and inferred reserves contain approximately 21.2 million tons of zinc of which approximately 16,300,000 tons is recoverable metal. There are also large areas of unexplored ground that may contain as much or more unknown ore that is not listed now in reserves. It seems doubtful that production will be increased, however, as most production beyond the current rate (July-September 1953) of 500,000 tons cannot be achieved under existing conditions and compete with production from abroad. Under conditions of strong demand for domestically mined zinc such as might be engendered by war or fostered by unusually high trade barriers domestic production could in a period of 1½ to 2 years again attain an annual rate of 675,000 to 700,000 tons.

Known reserves of zinc ore in Canada and Mexico approximate 8.5 million tons and since the domestic requirements of these 2 nations averaged but slightly over 61,000 per annum in the period 1948–52 while their average mine production was 535,000 tons there normally remains an exportable surplus of almost 475,000 tons. Such a quantity of zinc combined with our own production of zinc is adequate to meet foreseeable United States consumption of primary zinc. Recent exploration programs in New Brunswick and Quebec have been successful in developing new reserves, and it seems likely that Canadian reserves will be maintained for many years.

Supplies of zinc are presently being imported from Bolivia, Chile, and Peru, and Argentina is a producer. Known reserves of recoverable zinc in South America exceed 5.0 million tons whereas production is about 140,000 tons and consumption averages but 25,000 tons per annum. Thus again it is noted that an export surplus of about 115,000 tons is annually available for export.

Salient statistics of the zinc industry in the United States in 1948–52

	1948	1949	1950	1951	1952
Production of primary slab zinc.....short tons..	787,764	814,782	843,467	881,633	904,479
Production of redistilled secondary slab zinc..do....	62,320	55,041	66,970	48,657	55,111
Total slab zinc production.....do....	850,084	869,823	910,437	930,290	959,590
Stocks at primary smelters.....do....	19,179	90,710	7,920	21,433	81,344
Stocks at secondary smelters.....do....	1,669	3,511	934	637	3,677
Stocks at consumers' plants.....do....	96,196	81,904	64,835	51,063	92,910
Total stocks of slab zinc.....do....	117,044	176,125	73,719	73,133	177,931
Mine production of recoverable zinc.....do....	629,977	593,203	623,375	681,189	666,001
Consumption of slab zinc.....do....	817,735	711,841	967,134	933,971	852,783
Imports of slab zinc.....do....	93,232	126,925	155,974	88,043	115,151
Imports of ores and concentrates (zinc content)..do....	264,203	241,179	278,573	302,875	448,699
Exports of slab zinc.....do....	65,537	58,709	12,917	36,510	57,714
Average quoted price, Prime Western grade, East St. Louis.....cents per pound..	13.58	12.15	13.88	17.99	16.21

Salient statistics of the zinc industry in the United States in 1953, by months

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Production of primary slab zinc short tons..	77,458	72,771	79,317	76,540	78,028	77,579	77,315	.....	.....
Production of redistilled secondary slab zinc.....short tons..	4,536	4,128	4,168	3,919	4,394	4,038	3,510	.....	.....
Total slab zinc production short tons..	81,994	76,899	83,485	80,459	82,422	81,617	80,825	83,241	81,144
Stocks at primary smelters short tons..	88,475	93,664	99,864	94,280	92,452	97,285	103,906	.....	.....
Stocks at secondary smelters short tons..	3,300	3,357	3,398	3,011	2,095	1,218	1,379	.....	.....
Stocks at consumers' plants short tons..	87,244	86,903	86,882	87,580	92,043	103,168	108,313	.....	.....
Total stocks of slab zinc short tons..	179,019	183,924	190,144	184,871	186,590	201,671	213,598	.....	.....
Mine production of recoverable zinc short tons..	54,035	49,506	51,803	51,335	47,940	46,413	42,252	41,034	.....
Consumption of slab zinc short tons..	89,103	84,098	94,452	91,544	88,426	85,859	73,031	.....	.....
Imports of slab zinc.....do....	20,853	18,471	21,918	27,141	26,892	39,031	26,220	.....	.....
Imports of ores and concentrates (zinc content).....short tons..	46,017	29,541	37,717	30,573	40,490	45,235	58,992	.....	.....
Exports of slab zinc.....do....	3,176	1,843	1,724	666	410	102	99	.....	.....
Average quoted price, Prime Western grade, East St. Louis cents per pound..	12.60	11.48	11.03	11.00	11.00	11.00	11.00	11.00	10.18

Source: Prepared by Base Metals Branch, U. S. Bureau of Mines, Oct. 14, 1953.

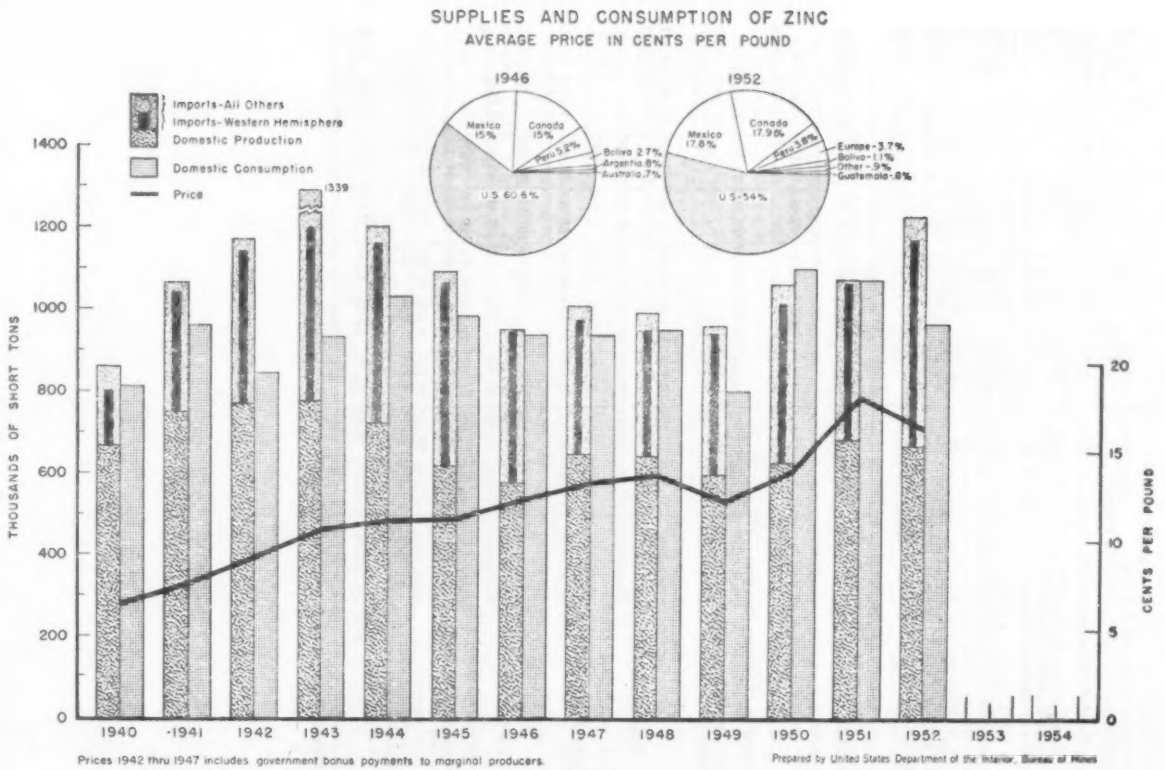

SUPPLIES AND CONSUMPTION OF ZINC
AVERAGE PRICE IN CENTS PER POUND
1946
1952
Imports-All Others
Imports-Western Hemisphere
Domestic Production
Domestic Consumption
Price
1339
Mexico 15%
Canada 15%
Peru 9.2%
Bolivia 2.7%
Argentia 8%
Australia 7%
U.S. 60.6%
Mexico 17.6%
Canada 17.9%
Peru 3.8%
Europe - 3.7%
Bolivia - 1.1%
Other - 9%
Guatemala - .8%
U.S. 54%
THOUSANDS OF SHORT TONS
CENTS PER POUND
1400
1200
1000
800
600
400
200
0
20
15
10
5
0
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
Prices 1942 thru 1947 includes government bonus payments to marginal producers.
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines

Figure 1

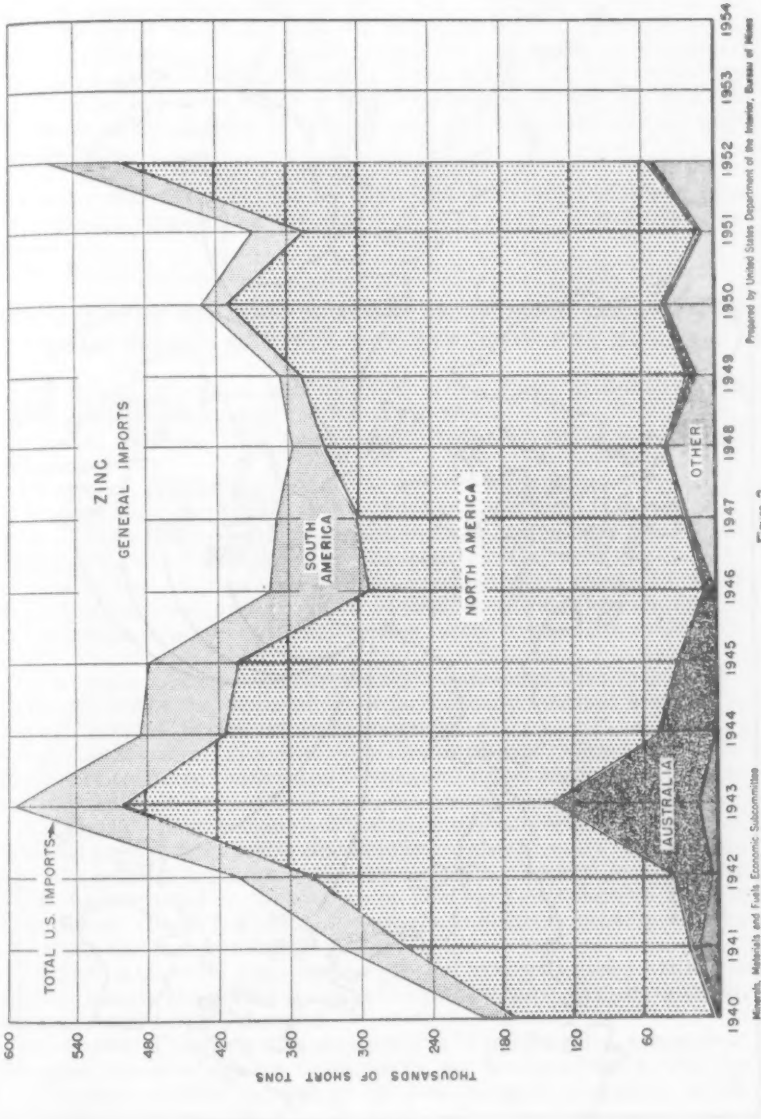

ZINC
GENERAL IMPORTS
TOTAL U.S. IMPORTS
SOUTH AMERICA
NORTH AMERICA
AUSTRALIA
OTHER
THOUSANDS OF SHORT TONS
600
540
480
420
360
300
240
180
120
60
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
Prepared by United States Department of the Interior, Bureau of Mines
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 2

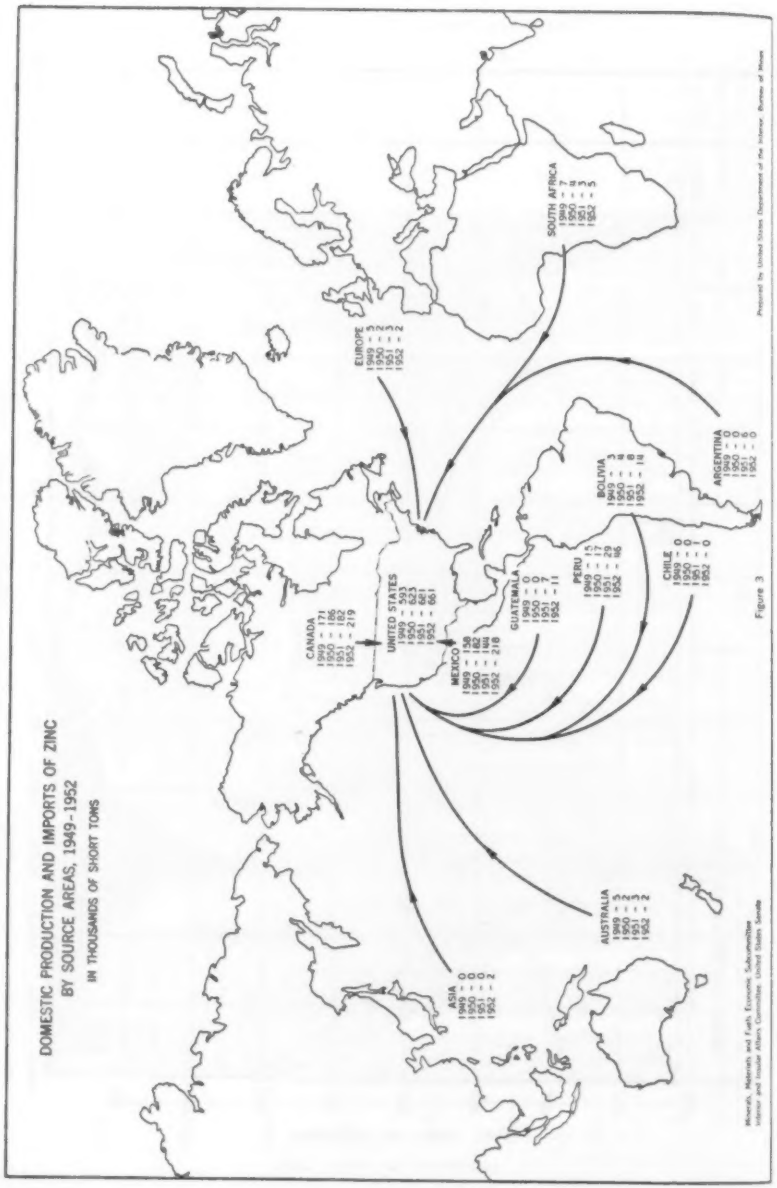

DOMESTIC PRODUCTION AND IMPORTS OF ZINC
BY SOURCE AREAS, 1949-1952
IN THOUSANDS OF SHORT TONS
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate
Prepared by United States Department of the Interior, Bureau of Mines
EUROPE
1949 = 2
1950 = 1
1951 = 1
1952 = 2
SOUTH AFRICA
1949 = 7
1950 = 4
1951 = 3
1952 = 3
CANADA
1949 = 171
1950 = 186
1951 = 182
1952 = 219
UNITED STATES
1949 = 593
1950 = 583
1951 = 681
1952 = 661
MEXICO
1949 = 58
1950 = 82
1951 = 144
1952 = 210
GUATEMALA
1949 = 0
1950 = 7
1951 = 7
1952 = 11
PERU
1949 = 17
1950 = 28
1951 = 28
1952 = 18
BOLIVIA
1949 = 3
1950 = 9
1951 = 8
1952 = 14
CHILE
1949 = 0
1950 = 1
1951 = 0
1952 = 0
ARGENTINA
1949 = 0
1950 = 0
1951 = 0
1952 = 0
AUSTRALIA
1949 = 5
1950 = 2
1951 = 2
1952 = 2
ASIA
1949 = 0
1950 = 0
1951 = 0
1952 = 2

Figure 3

Senator MALONE. Does that complete your field?

Mr. JOHNSON. That completes my testimony, sir.

Senator MALONE. Mr. Johnson, at your convenience and within a reasonable time—we resume the hearings in Washington about the 15th or 16th of November; we will have a hearing on the 12th on uranium ore at Salt Lake City—if you have further information on possible substitutes for the metals in your field, the status of laboratory work, and any further information which would help the committee to obtain its objective, which is to determine the availability of these materials to this Nation in time of war, the committee will be very appreciative.

Mr. JOHNSON. I will be very glad to do that.

Senator MALONE. Not only for the next 1 or 2 years, but what might be a definite program for the next 5 years or more. Thank you very much.

Mr. Kline.

STATEMENT OF MITCHELL H. KLINE, CHIEF, RARE AND PRECIOUS METALS, BUREAU OF MINES, DEPARTMENT OF THE INTERIOR

Mr. KLINE. My name is Mitchell H. Kline, Chief of the Rare and Precious Metals Branch of the Bureau of Mines.

Senator MALONE. You are familiar with the objectives of this committee?

Mr. KLINE. That is correct.

Senator MALONE. Thank you. Go ahead.

Mr. KLINE. The rare and precious metals field covers some 40 or more metals which are obviously scarce or little known and relatively of great value. As new uses are discovered for the rare metals, their value becomes even greater. The problem in the rare metals field is not to maintain a mining industry, but rather to establish and foster one.

To provide techniques to nurture these industries often becomes the responsibility of the Government, a fact already demonstrated in the case of titanium, zirconium, and rare earths.

Senator MALONE. Titanium and zirconium, and especially zirconium, resulted from the demand for metals to meet higher temperature requirements?

Mr. KLINE. That was one of the main considerations. The other is due to zirconium's special characteristics which highly recommends its use in reactors in the atomic energy program. In fact, Senator, you might be interested in this. I know you have considerable interest in titanium. There is a piece of titanium, and this is zirconium. The nice shiny one is zirconium.

Senator MALONE. I hope as you proceed you will give us the uses of these metals, the money value at the present time, present demand, and estimated further demand.

Mr. KLINE. Titanium only enters my field incidentally, except that the procedure by which the Government has developed the processing of titanium is similar to what we are now doing on zirconium, which falls within my province.

Only a very few years ago the wonder metal, titanium, was in the rare metals category. Many fascinating possibilities still remain among the rare metals to attract the research minded, and at present zirconium is our "rags to riches" performer. It is certain that within a short time zirconium will be in as great demand as titanium, but of course will not necessarily have the same applications.

Because of the time limitation imposed on these hearings, discussion will be held to only those metals which are presently known to be most essential in time of emergency. The fact that many metals are produced in small quantities and are less familiar to the public does not in any sense reflect their importance, nor imply that in the future they may not be more essential than the presently recognized more familiar strategic metals. Uranium and thorium cannot be discussed in open hearings, and a report on these metals will be deferred to another time.

I should like to hurriedly review the present situation with regard to the most urgent and important commodities in this group. Unless otherwise instructed, I plan to limit my statements to beryllium, columbium, tantalum, zirconium, hafnium, rare earths, selenium, and platinum.

BERYLLIUM

I will start with a discussion on beryllium. I would like at this time to distinguish between beryllium and beryl. Beryllium is the metal and beryl is the ore. The United States has been over 80 percent dependent on foreign sources for this material. The growth of the domestic beryllium industry has been limited by a lack of assured supply of ore. All beryl is recovered by hand sorting method. Recovery is probably not more than 30 percent. Beryl is a pegmatite mineral. The recovery of beryl from pegmatites is a formidable mining and metallurgical problem.

Commercial grade beryl contains an average of 10 percent BeO, or 3.6 percent Be. In processing, recovery is about 70 percent. Thus, there is 2.5 percent recoverable Be in beryl.

Production in the United States is approximately one-sixth of our consumption. Beryllium has many important uses, especially as an alloying agent with copper, alumium, iron, and manganese. It is unsurpassed in ability to withstand fatigue and wear and at the same time conduct electrical current, even at high temperatures. Applications are in springs and contacts in tabulating machines and in electronic equipment; military use in diaphragms and bellows for numerous instruments and gages. Beryllium copper is excellent for casting intricate parts. It can be worked in soft state and brought to final level of strength and hardness by simple heat treatment.

Beryllium oxide is an excellent refractory material, used in aircraft sparkplugs, high-frequency insulators, rocket combustion chambers, and in nuclear energy powerplants.

Beryllium metal is used principally in the atomic energy field, as a moderator and as a reflector of neutrons. The use of beryllium is curtailed by scarcity and high price. Otherwise, it would be used in preference to several other materials.

Zirconium, although a greater absorber of neutrons than beryllium, is used in nuclear powerplant construction because of its availability and lower cost. The chief problems of the industry are first an inadequate supply of beryl concentrates; second, a continuing policy with

regard to the usage and the availability of beryl stocks. The third problem is one of technology; the matter of working out an adequate and satisfactory mining method and determining a metallurgical process which will extract beryl from the pegmatite ores within the limits of economic practicability.

In regard to this metal, the most practical solution to our problems seems to be, (1) a stockpile sufficiently large to take care of emergency requirements for 5 years. The cost of such a stockpile would be relatively modest, probably on the order of $10 million to $12 million.

The second solution to our situation would be the development of a successful milling method to recover beryl from low-grade deposits.

Beryl reserves in milling rock in the United States are estimated at 270,000 tons, as compared with some 6,000 tons that can be recovered by hand-sorting methods. These larger reserves could be made available to industry only after suitable mining and metallurgical methods have been devised. This ultimate requirement to guarantee national self-sufficiency could probably be met by a 5-year research program, if funds were available over this period at an annual rate of about $75,000 a year.

Senator MALONE. That is for laboratory research work?

Mr. KLINE. Yes, sir. I would like to emphasize the importance of having money available over a period from 3 to 5 years, because in this type of technical problem it is impossible to set up a program in a year unless you have some assurance of continuity. We cannot acquire the personnel or continue the research phases of the operation over a sufficient length of time to accomplish anything worthwhile.

Senator MALONE. We are probably in the vanguard of these research and laboratory operations. That is to say, no other friendly foreign nation, at least, is ahead of us.

Mr. KLINE. Certainly not. As a matter of fact, we have had some very encouraging results to date from the little amount of work that we have been able to do.

Senator MALONE. We are then in an absolutely new field not hitherto extensively investigated, because of lack of demand. Demand is now putting us in the field and we are in it because we are unable to get the information elsewhere.

Mr. KLINE. The lack of demand at present is considerable, and it would be great if industry could obtain the material for us. The trouble has been in the past that when adequate stocks of the material are available, the industry is afraid to use the metal because they know as soon as an emergency arises, there will be a shortage, and they will have to discontinue their use.

Senator MALONE. It is right in line with the titanium supply at the present time.

Mr. KLINE. The same sort of situation.

Senator MALONE. Go ahead.

COLUMBIUM AND TANTALUM

Mr. KLINE. The next two metals in this group, columbium and tantalum, will be reported together, since they are closely related. The United States is entirely dependent on foreign supply for these strategic metals. Over 97 percent comes from Eastern Hemisphere sources, largely Africa. Large potential reserves exist in the United

States, but await the development of successful beneficiation methods and metallurgical extractive processes. Refinery capacity appears to be ample for emergency demands.

Like beryl, columbium and tantalum minerals originate generally and commonly in pegmatites. Columbite imports contain an average of 67 percent combined pentoxides and 50 percent combined metal. Because of the wide range in grade of columbite-tantalum concentrates, data are given in terms of the combined metals. United States production is about 2,500 pounds annually of columbium and tantalum, and the consumption figures are confidential, but many, many times greater.

The most important use of columbium and tantalum is in the manufacture of high-temperature steels and alloys used in jet aircraft engines. Other uses for columbium include electronic tubes and low voltage rectifiers, electrodes for welding stainless steel, and as an oxide in ceramics.

Tantalum is important in the manufacture of electronic equipment and chemical equipment, because of its resistance to corrosion, and it is also used largely in dies and cutting tools as a carbide. It is used as an activator also in the synthetic-rubber industry.

No satisfactory all-around substitute has been developed for use in high-temperature alloys. Titanium is acceptable in certain applications and a nickel base alloy with additions of titanium, aluminum, and chromium, is reported to be promising.

Zirconium might substitute for tantalum as a material for construction in the chemical industry. The problems of the industry are almost identical with the problems offered in the case of beryl and the solution is almost identical. As a matter of self defense, the only recommendation that can be made is a stockpile to meet emergency requirements for 5 years. Again, the amount involved is relatively small in consideration of the satisfaction derived from having such a stockpile in existence.

The second solution to the problem is almost identical again with beryl, to improve the long range situation, the continued exploration and development of potential deposits of these minerals, both lode and placer, must be continued and the research program must be extended and expanded not only in the field of beneficiation, but in extractive metallurgy.

Again a 5-year program would probably solve the problem. The rate of financing would have to be of the same order as for beryl, that is, $75,000 annually.

Senator MALONE. If I understand your testimony, to become self-sufficient in the production of these materials in the United States, this program would have to be pursued.

Mr. KLINE. Absolutely.

Senator MALONE. And that you believe self-sufficiency could be achieved within a reasonable time, perhaps within 5 years?

Mr. KLINE. I am very optimistic about that. I believe we can solve the problem in that length of time, provided we had continuity in the program.

Senator MALONE. Say 3 to 5 years.

Mr. KLINE. Yes, sir.

Senator MALONE. The use for these materials is so new that heretofore the demand has not been sufficiently urgent to justify recommendations for the work you are now doing.

Mr. KLINE. That is true of nearly all of these metals. There is not any doubt in my mind that the same thing will happen with regard to their use as has happened with titanium, aluminum, and zirconium. Every time we have had a new metal that we could produce in quantity there has at first been a short time when we had more metal than we could use, because people did not know what to do with it. As soon as they had studied the physical characteristics and knew its properties we have had difficulty maintaining sufficient supplies to satisfy the demand.

Senator MALONE. But when the market is established just as you have outlined here, and you mentioned titanium, there is little doubt that we could become reasonably self-sufficient. There is no shortage of raw-material supplies in this Nation and Canada. Ilmenite is a little different from the rutile that we are obtaining from Australia.

Mr. KLINE. I am reasonably sure that in the Western Hemisphere once we have developed a satisfactory mining method and an economic metallurgical process for extracting the metals, there will be no difficulty in keeping up with demand, even though I expect the demand to be much higher.

The situation is the same with beryl. People are reluctant to use these things because they are not sure they can get the metal when they need it.

Senator MALONE. That is exactly the complaint we are receiving in titanium. You were speaking of titanium.

Mr. KLINE. Yes, sir; as a comparison.

Senator MALONE. But all these rare metals you are describing today are in the same category? When demand and a profitable price are established, there is no question in your mind that through such a program as you are describing we can become self-sufficient in the Western Hemisphere and increasingly productive in our Nation.

Mr. KLINE. I am quite certain of that.

Senator MALONE. There was considerable testimony before the committee on the availability of the ilmenite raw material being almost readily available in Canada and the United States if we changed over from rutile.

Mr. KLINE. Going back to columbium and tantalum, within the last 2 years we have discovered a type property which is entirely new in the mining field. Dredges are being moved into that property right now. By next year it will be in production. We believe we are far enough along with the beneficiation processes and extractive processes so that within 2 years we can do a great deal to attain self-sufficiency right within the United States.

Senator MALONE. That is with reference to what metal?

Mr. KLINE. Columbium and tantalum.

Senator MALONE. That is very, very interesting. One of the purposes of this committee is to bring out exactly the testimony you are offering, as to what can be done, over what period, and what it would cost. You may proceed. This is your prepared statement on beryl?

Mr. KLINE. That is right. I would like to have it entered as a part of my testimony.

Senator MALONE. There are no charts prepared on this material because the production has been so small.

Mr. KLINE. I might add in a few cases where we have been able to put them on the chart, the chart is absolutely misleading.

Senator MALONE. Then this text on beryllium will be accepted as a part of Mr. Kline's testimony, and appear at this point in the record.

Mr. KLINE. This is the text on columbium and tantalum.

Senator MALONE. That will be accepted and appear at this point in the record, and appear as part of Mr. Kline's testimony.

(The information is as follows:)

BERYLLIUM (BERYL)

Mine production of beryl in the United States has accounted for less than 10 percent of our total supply during the past 6 years. To emphasize our dependency on foreign sources of supply, known United States reserves of beryl that can be recovered by present methods are less than 7,000 short tons; less than 3 years' supply, based on the 1952 consumption rate. Production and known reserves of Canada and Mexico are too small to be of any significance.

Brazil has been the principal source of supply and Argentina, a large potential source. Over 500 tons of beryl were imported from Argentina in 1952, the first large shipments since 1943. During the period 1947–52, 53 percent of our total supply came from South America (50 percent from Brazil). Southern Rhodesia and Union of South Africa (including South West Africa) have become important sources of beryl since 1950, accounting for 43 percent of our total supply during the period 1950–52. Mozambique, French Morocco, India, and Portugal have supplied appreciable quantities. Western Hemispheric sources of supply and reserves are ample for present consumption rates. In time of emergency or in view of anticipated expanded consumption rates Western Hemispheric sources of beryl will fall short of requirements. Production from the larger known reserves in pegmatites will not be increased unless advances in technology make possible the beneficiation of these ores so that a marketable concentrate can be recovered.

USES

Beryllium has important applications in the form of an alloying element with copper, aluminum, nickel, magnesium, and iron; as beryllium oxide in the manufacture of specialized high-temperature refractory material and high-quality electrical porcelains; and as a metal in the atomic-energy field as a moderator and as a reflector of neutrons, in radium-beryllium neutron sources, and in X-ray tube windows. In terms of quantity, the largest use is in the manufacture of beryllium-copper alloys. These alloys are unsurpassed in their ability to withstand fatigue and wear and at the same time conduct electrical current under high-temperature conditions. They are unique among copper-base alloys in that they can be worked in a relatively soft state and then brought to their final level of strength and hardness by simple low-temperature heat treatment. No entirely satisfactory substitute has yet been developed. In 1952 an estimated 65 percent of all beryllium products was utilized for defense purposes. The free world is almost entirely dependent on the United States for beryllium copper.

RESOURCES

Canada

Numerous occurrences of beryl, most of which are associated with pegmatite dikes, are known in Canada, but only token quantities have been recovered. In 1950 a 29-metric-ton shipment of beryllium ore from Renfrew County, Ontario, was exported to the United States; and since 1950 there has been some active interest in beryl occurrences in other parts of the Dominion, notably in Manitoba and Quebec. Although Canada possesses some production potential, imports of elemental beryllium in alloys, metal, and crude forms are normally in excess of domestic production.

Brazil

Brazil has been the world's leading producer of beryl since 1940. Its greatest exportation was 3,386 short tons of concentrates, or 69 percent of world production in 1949. In 1952 exports to the United States were 2,590 short tons or about 37 percent of world production, and about 47 percent of United States imports. Commercial concentrates contain about 10 percent BeO.

In January 1951 Brazil placed a complete export restriction on beryl, which caused a critical shortage in the United States, but relaxed it the following July. A limited restriction is still in force.

A partial survey made by the Beryllium Corp. in the Minas Gerais and Bahia regions of Brazil showed an estimated proved figure of 40,000 tons. Other surveys and opinions indicate a possible reserve of 200,000 tons in this area. Estimates that there is 50 percent more beryl in the north and northeast of Brazil than in Minas or Bahia bring the "guesstimated" reserve to 500,000 tons for Brazil.

Argentina

Beryl production from Argentina has varied widely. It has been as high as 2,405 short tons of concentrates in 1941 and as low as 11 tons in 1947. In 1952, 550 short tons were exported to the United States. This exportation came from an 8 years' accumulation of stocks, during which time no exports were permitted. The present rate of production and that for some time past is thought to be about 30 tons of concentrates per month.

The Guianas

Beryl is known to exist in French Guiana, Surinam, and British Guiana, and some exploration of the Surinam deposits is currently under way. However, production has not yet been attempted, and an appraisal of the potential is not possible at present.

PROBLEMS OF INDUSTRY

The lack of an assured supply of beryllium ore has curtailed the growth of the beryllium industry. The supply situation has fluctuated—periods of oversupply followed by periods of acute shortages. This condition has made it difficult for the beryllium industry to develop a steady, commercial market. For example, during times of emergency when beryllium is used primarily for defense purposes, commercial users are forced to find substitutes. When defense demands decrease, a period of time is required to again develop commercial applications. This lack of an assured supply from the primary producers has made manufacturers of end-use products reluctant to gear their industry to beryllium, although beryllium products have recognized, superior qualities. The solution to this problem would undoubtedly result in the expansion of the beryllium industry.

Ore minerals of beryllium have not been recovered in quantities comparable to those of the more familiar metals—for example, lead, copper, and zinc—for two reasons:

(1) The properties of the element beryllium are such that it is concentrated in appreciable quantities only in late stages of magmatic activity. Consequently, the occurrence of beryllium minerals is spasmodic, erratic, and difficult to predict.

(2) No successful commercial method to recover beryllium minerals by mechanical methods has yet been developed. Beryl is recovered entirely by hand-sorting (cobbing) methods; recovery probably does not average over 30 percent.

An appreciable increase in the domestic production of beryl will depend on the development of a successful method to recover fine-grained beryl from large, low-grade deposits. Although the price of beryl has risen 50 percent since 1949, domestic production has remained at about the same level. Domestic reserves of beryl that can be recovered only by milling have been estimated at 270,000 tons, and other similar deposits are being investigated.

RECOMMENDATIONS

Although the beryl supply situation improved in 1952 and the first 7 months of 1953, every effort should be made to achieve the stockpile objectives as soon as possible. In periods of oversupply, consideration should be given to stockpiling beryllium-copper master alloy (a more immediately usable material in times of emergency) in order to maintain a healthy beryllium industry. Unless a successful milling method is developed, the anticipated supply will fall short of requirements in times of emergency; and may fall short even with success in recovering

beryl from large, low-grade deposits. The strategic nature of beryllium alloys, metal, and compounds dictates the necessity of an ample supply.

The development of a successful milling method appears to be the most practical long-range means of increasing substantially domestic beryl production. In addition, other beryllium-mineral deposits, such as the helvite deposits of New Mexico, should be investigated. This study will entail both mineral dressing and extractive metallurgical studies, since the beryllium industry is at present not adapted to the use of helvite (a beryllium sulfosilicate). The commercial occurrence of beryllium minerals such as phenacite and gadolinite should be investigated. Commercial deposits of phenacite, because of its similarity to quartz may have been overlooked. Funds for the suggested programs should be provided over a period of 3 or more years because the successful completion of any phase will depend on noninterrupted, continued studies. Personnel, equipment, and material problems are difficult to solve on an intermittent basis. If funds in the amount of $75,000 per year could be provided over a period of 5 years, this long-range objective could probably be obtained.

Columbium and Tantalum

Columbium-tantalum minerals are mined in the United States entirely as a byproduct of other minerals. There are no columbium-tantalum mines as such. These two rare metals are among those most vital for defense. The United States produces less than 1 percent of its annual columbite-tantalite requirements. Columbite was mined in Colorado and South Dakota as early as 1904. From 1947 to 1951 about 7,000 pounds of columbite-tantalite were produced domestically, principally from the Black Hills, S. Dak.; Texas City and Ohio City, Colo.; and from the Harding mine near Dixon, N. Mex. In 1952, over 5,000 pounds of columbite concentrates were recovered as a byproduct of pegmatite mining operations in North Carolina. Columbium occurs associated with some Arkansas bauxites; with the titanium minerals in the area of Magnet Cove, Ark., and Florida; and significant quantities of columbium-tantalum minerals are associated with other minerals of economic importance in the placer sands of Idaho.

RESERVES

More than 90 percent of the world production of columbite-tantalite ores comes from Nigeria and Belgian Congo in the course of placer tin-mining operations; production fluctuates with the activity in the tin fields. About 6 percent columbite-tantalite is contained in the cassiterite rougher concentrate; this product is treated electromagnetically and about 75 percent of the columbite-tantalite content removed. The balance of the columbium-tantalum reports in the slag resulting from the tin-smelting operation.

The principal foreign columbite producing countries, in the order of their importance, are Nigeria, Belgian Congo, Brazil, Uganda, Portugal, and Mozambique; minor quantities have been produced in India, Union of South Africa, Bolivia, and Argentina. Tantalite and other tantalum-bearing minerals have been produced principally by Belgian Congo, Brazil, and Australia; minor quantities have come from Southern Rhodesia, Uganda, Nigeria, South West Africa, Union of South Africa, Argentina, the Federation of Malaya, India, and Canada.

Imports of tin smelter slag from Nigeria, Belgian Congo, Portugal, and Malaya have become an important source of columbium and tantalum since 1951.

The extent of columbium-tantalum reserves is uncertain, but the free world reserves are insufficient to meet greatly increased demands in time of emergency. Known reserves of columbite in South Dakota, North Carolina, Arizona, and Colorado have been estimated at about 250,000 pounds. This estimate does not include the columbite content of the bauxites of Pulaski and Saline Counties, Ark., and the columbium-bearing titanium minerals in the Magnet Cove, Ark., area. Tantalite reserves have been estimated at about 130,000 pounds, and microlite, a calcium tantalate, at about 600,000 pounds. Substantial quantities of columbium-tantalum minerals have been discovered associated with monazite in the placers of Idaho. Known placer deposits in Idaho, amenable to dredging operations, are estimated to contain 10 million pounds of columbium-tantalum metal. However, concentration, separation, and metallurgical extraction processes must be perfected before these deposits can be exploited.

Foreign columbite reserves, chiefly in Nigeria, are estimated to be about 30 million pounds. The Belgian Congo has large reserves of low-grade columbite-tantalite ore; estimates in the order of 50 million pounds have been reported.

Reserves of high-grade tantalite have been estimated at 5 million pounds, of which 4 million pounds is in Brazil. Insufficient data are available relative to koppite deposits in Germany and Norway, pyrochlore deposits in Nigeria and Northern Rhodesia, and ellsworthite deposits in Ontario, Canada, to include these deposits in world reserves.

USES

High-temperature alloys, important to jet engines and gas turbines, are now in competition with the heat- and corrosion-resistant stainless steels for the world's limited supply of columbium. The primary use of columbium (ferrocolumbium and ferrocolumbium-tantalum) at present is in the manufacture of stabilized austenitic (chromium-nickel) stainless steels. It is also used as a means of reducing the air-hardening characteristics and increases the toughness, weldability, ductility, and corrosion resistance of plain chromium steels. In corrosion resistant steel castings that require welding without subsequent heat-treatment, the harmful effect of carbide precipitation may be eliminated by adding columbium to the steel. The carbon in the alloy preferentially combines with the columbium instead of the chromium. Crystal boundaries thus retain their chromium content and intergranular and intercrystalline corrosion does not occur. The weldability, and creep and impact strength are also increased. Columbium is an important additive to supertemperature steels when used in concentrations of 1–5 percent; again strength and resistance to creep at high temperatures are the important properties. The life and efficiency of jet engines are dependent upon these properties. Ferrocolumbium contains 40–50 percent columbium, and ferrocolumium-tantalum contains about 60 percent combined columbium and tantalum. A chromium-nickel-columbium steel has strength properties adequate for applications such as rotor forgings, blades, and tubes used in gas turbines.

At high temperatures columbium has excellent electron emission characteristics, and because it will absorb the common gases it is used as a getter in vacuum tubes. Columbium is a better absorber of gases than tantalum; it can be used, therefore, in electronic tubes where service requirements are severe. Columbium can also be employed as a rectifier of low-voltage alternating current. The resistance to attack by many acids is of interest to the chemical industry. It is also used as a cathode material for the electrolytic determination of copper, zinc, silver, and nickel. Columbium is superior to tantalum for this purpose, having characteristics similar to platinum. It is used also in electrodes for welding stainless steel and in the manufacture of special magnet alloys. The estimated distribution of columbium in 1952 was, by use, as follows: As ferrocolumbium and ferrotantalum-columbium in steel, 60 percent; specialized nonferrous alloys, 30 percent; cemented carbides, 5 percent; welding rods and miscellaneous, 5 percent.

In many respects tantalum is analogous to the noble metals: Gold, silver, and the platinum group. Unlike the noble metals, however, tantalum is not found in elemental form in ore deposits. Because of its inert properties—ductility, malleability, and toughness—tantalum was used prior to 1952 largely in the chemical industry as a material of construction and in electronic application. With the increased use of high-temperature metals, the demand for columbium exceeded its availability. To alleviate this shortage, a ferrotantalum-columbium alloy was developed containing approximately 20 percent tantalum and 40 percent columbium; columbium ores usually contain substantial quantities of tantalum. From the standpoint of high-temperature strength, columbium and tantalum can be used interchangeably or in combination; however, on a weight basis tantalum has the disadvantage of an atomic weight double that of columbium. As a result of ferrotantalum-columbium being substituted for ferrocolumbium, the largest use of tantalum in 1952 was in the steel and alloy industry. Tantalum in metal form continued to have important uses in electronic tubes, electrolytic capacitors, chemical equipment, and in surgical and dental supplies; in the form of the carbide, in dies and cutting tools; and, as K_2TaF_7, as an activator in the synthetic rubber industry. As a material of construction for corrosive chemicals, tantalum, because of its high thermal conductivity, is used principally in heat exchangers of the shell-and-tube, coil, and bayonet type. The estimated distribution of tatalum in 1952 was, by use, as follows: As ferrotantalum-columbium in steel, 28 percent; electronic uses, 25 percent (electronic tubes, 18 percent; electrolytic capacitors, 7 percent); as tantalum carbide, 16 percent; chemical equipment, 15 percent; in the synthetic-rubber industry, 12 percent; and for surgical, dental, and other purposes, 4 percent.

SUBSTITUTES

The lack of an adequate supply of either columbium or tantalum has stimulated the search for substitutes. No suitable all-round substitute for columbium has been developed, although titanium is usable in some cases. Investigations have been made using titanium, vanadium, and tantalum as substitutes for columbium. Titanium is an acceptable substitute for columbium in 18–8-type stainless steels for a majority of applications. The use of ferrocolumbium-tantalum, made from low-grade ores, has conserved some columbium. Lowering the carbon content and therefore the columbium needed to stabilize 18–8-type stainless steels is another way of saving this critical metal. Substantial quantities of columbium may be conserved, for more critical uses, by recent developments permitting the substitution of low-carbon (0.02–0.03 percent) stainless steel for columbium stabilized steel for certain applications.

Tantalum can be replaced for certain applications by zirconium, tungsten, molybdenum, and platinum. Zirconium (ductile) is lighter, cheaper, and just as corrosion resistant as tantalum and eventually (when zirconium is available to industry in quantity) probably will be used for many applications requiring tantalum today; in chemical plant equipment, surgical appliances and equipment, and in vacuum tubes. Molybdenum and tungsten tools have been substituted but for certain purposes were not considered as desirable as tantalum carbide. Columbium carbide has been substituted but this does not contribute to the conservation of columbium. In the manufacture of certain radio tubes, zirconium-coated molybdenum, platinum-coated molybdenum, and platinum and graphite have been substituted for tantalum. For some tubes these substitutions are not acceptable. Platinum can be used in place of tantalum for some chemical uses. No satisfactory substitute has been devolped for the use of tantalum potassium fluoride as a synthetic-rubber catalyst.

PROBLEMS OF INDUSTRY

Shortage of columbium-tantalum ore, during periods of emergency, and the guaranty of a steady market for the products of the ore, during normal periods, constitute the major problem of the industry. The requirements of defense programs make it necessary to allocate the supplies of columbium-tantalum products for this purpose. When defense demands decrease, a period of time is required to regain commercial markets. Government regulations relative to end uses are often in force after defense demands are decreased, thus creating an oversupply on the part of the producer. If new or expanded uses are developed for columbium and tantalum, this situation may not materialize.

The United States, the largest consumer of columbium-tantalum minerals in the world, is now able to supply less than 1 percent of its requirements. The metallurgical know-how and ingenuity of United States technicians will eventually release to industry the columbium-tantalum minerals now locked in the many types of low-grade deposits distributed throughout the United States. The contribution will be significant but probably never more than 50 percent of domestic requirements will be reached during periods of emergency.

One of the more troublesome factors in columbium-tantalum metallurgical investigations has been the lack of a rapid, accurate, analytical control procedure. The successful development of such a procedure will aid materially the successful completion of investigations to recover columbium-tantalum from low-grade deposits.

RECOMMENDATIONS

In view of almost complete dependency on foreign sources for our supply of highly strategic columbium-tantalum and the necessity of keeping sea lanes open in times of emergency, every effort should be made to achieve the stockpile objectives as soon as possible. Consideration should be given to stockpiling ferrocolumbium and ferrotantalum-columbium (more immediately usable materials than columbite-tantalite) as an aid in maintaining a healthy industry.

In order to meet requirements for columbium-tantalum, emphasis must be placed upon developing both domestic and foreign deposits. Funds allotted for programs should be prorated over a period of three or more years. The successful completion of any phase will depend on noninterrupted, continued studies. Personnel, equipment, and technological problems are difficult to solve on an intermittent basis. Funds should be provided at the rate of $75,000 per year for research on metallurgical problems and field investigations for a period of at least 3 years.

Senator MALONE. I have a question before we go on. Does the State Department or any department of government have any part in the arrangements with foreign governments for beryl, columbium, and tantalum shipments to the United States?

Mr. KLINE. In the case of beryllium, the State Department has played a very large role in regulating imports of the material, because a great deal of it has been imported. In fact, the major part of it has been imported.

Senator MALONE. Would you like to describe just what this relationship is at the present time?

Mr. KLINE. I am not certain of the mechanics of the operation, Senator. I do know that they make most of the arrangements with the nations regarding the shipments of beryllium, and they do have contact and participation in the arrangements on columbium and tantalum.

Senator MALONE. Go right ahead.

ZIRCONIUM AND HAFNIUM

Mr. KLINE. The two metals, zirconium and hafnium, will be described together because of their very close association and nature. Both of these metals are won from a mineral called zircon. All of the zirconium and hafnium that has been produced and is being produced is from that source. The reserves and production capacity for zircon, the commercial ore for zirconium, are ample for any foreseeable demand.

Senator MALONE. Domestic reserves?

Mr. KLINE. Yes; we have a superabundance of domestic reserves. Imports from Australia are comparable to domestic production because of lower price and a tie-in with the export of rutile. The limited refinery capacity and inadequate metallurgical processes are limiting factors controlling the growth of metallic applications.

Senator MALONE. Then there is really no reason for the importation of this zircon raw material?

Mr. KLINE. Absolutely not, other than by arrangement between this Government and the Australian Government, I believe, so we can obtain the rutile.

Senator MALONE. You mean as the price of shipping us rutile, they require us to accept zircon?

Mr. KLINE. That is right.

Senator MALONE. Would this not be an incentive to use local ores, such as ilmenite or a location of sufficient rutile in our production of titanium?

Mr. KLINE. I think there is every reason in the world to use our domestic minerals in the production of titanium and zirconium in preference to the foreign.

Senator MALONE. Is there any real problem in using the local ores, such as ilmenite, for use in the production of titanium?

Mr. KLINE. There is a problem.

Senator MALONE. Is it insurmountable?

Mr. KLINE. I think it is not, but Mr. Blue will cover that. Zircon contains about 50 percent zirconium and about 1 to 2 percent hafnium.

Senator MALONE. There is no scarcity of zircon in this country?

Mr. KLINE. We have a superabundance.

Senator MALONE. This is a little like during the war days when an entertainment organization purchased some good liquor; they were also required to purchase a few cases of secondary products.

Mr. KLINE. I usually try to stay on the better grades.

Senator MALONE. That is the answer. I think we should do that here.

Mr. KLINE. The consumption to date of zircon for metallic purposes is small when compared with its other uses. As has already been pointed out, we are producing about half of what we consume but we could produce any amount.

In discussing the uses of zirconium I am going to emphasize the metal, rather than the mineral zircon, although zircon also has some important uses. But there is no shortage of the mineral.

In the construction of nuclear reactor powerplants, because of its physical properties, resistance to heat and corrosion, and low thermal neutron absorbion cross section, zirconium has no substitute. Its special corrosion-resistant alloys are ideal for handling some chemicals. Many other uses for the metal will develop as soon as it is available to industry in greater quantity.

Hafnium, which is closely tied in with the extractive processes, is also an essential metal for the atomic energy program.

Senator MALONE. The headline that we are going to construct a commercial reactor in yesterday afternoon's papers and this morning should interest you greatly.

Mr. KLINE. I saw that in this morning's paper.

Senator MALONE. I have been familiar with that development for at least 3 or 4 years, and it was thought for a while that the Government would build a small reactor, a sort of pilot plant reactor of 15,000, 20,000 or 25,000 kilowatts. They had examined and some of the technicians had settled on the idea of putting it in Eureka, Nev., where it is estimated there is $150 million worth of lead and zinc at the bottom of the shaft, which required 12,000 to 15,000 gallons of water, and costs about 2½ cents a kilowatt-hour for power. But when they decided on the large one, it was too large for that area. They are not going to build it there. I am glad they are going to build it. There is no question of its feasibility in an area where the power costs are low.

Mr. KLINE. Considering the enormous reserves of raw material, zircon, it is unfortunate that more advantage is not being taken of the desirable properties of zirconium and its alloys. Hafnium now produced in conjunction with the production of hafnium free zirconium is available for the first time in quantities ample for experimental purposes. Continued research aimed toward producing zirconium and devising continuous metallurgical process for its production is imperative. Further alloy studies and investigations to determine other uses of zirconium and hafnium must be continued.

It is interesting to mention at this point that all the zirconium produced in the United States is produced by the Bureau of Mines, and the same is true of hafnium.

Senator MALONE. I am familiar with your development in Oregon. I think it is a great piece of work. Just as were your investigations in titanium at Boulder City.

Mr. KLINE. You are also probably aware, Senator, that there are other industrial concerns that are owned privately that are going to adopt our method and go into production.

Senator MALONE. Yes; generally speaking, I am. Of course, knowing of these developments, it probably accounts for one of the main reasons that I undergo a slow burn when I hear people taking for granted, and some of our high officials stating, that we are dependent for certain raw materials on foreign nations, and therefore we must do practically what they say we must do. It is a mild case of blackmail in a lot of these cases. If the information you men have in the Bureau of Mines were generally known, I think a lot of people could relax.

Mr. KLINE. Again, Senator, it is interesting to note that we are not now presently able to produce sufficient zirconium or hafnium to meet our domestic requirements. That is the reason other people are invited in. This is my statement.

Senator MALONE. The statement on zirconium and hafnium will be accepted, and appear at this point in the record as a part of Mr. Kline's statement.

(The information is as follows:)

ZIRCONIUM AND HAFNIUM

Zircon, the principal source mineral of zirconium and hafnium, is unique among rare-metal minerals in that deposits from which zircon can be extracted economically are plentiful. Sufficient zircon can be recovered in conjunction with titanium-mineral mining operations in Florida to meet present and estimated future demands. Known placer deposits in Florida, California, Idaho, and Oregon are estimated to contain 15 million tons of zircon. These reserves could be increased substantially if demand for zircon warranted intensive exploratory campaigns.

Zircon reserves in other parts of the world are known to be extensive. Brazil is known to have large reserves of zircon in beach deposits and over 2 million tons of the mineral baddeleyite (ZrO_2) in rock deposits. Australia contains enormous reserves of zircon and is the principal source of zircon imports for the United States. These imports are tied in with imports of rutile, a mineral in shorter supply. Large zircon deposits are known in India, Egypt, and French West Africa.

Most zircon contains small quantities of hafnium, a metal formerly of little interest, which had not been separated from the metallic zirconium produced from zircon. Recently, however, it has been found that the hafnium content is detrimental in certain atomic-energy applications of metallic zirconium. Hafnium-free zirconium is now being prepared and a limited amount of metallic hafnium is being produced. Hafnium has atomic-energy uses that are due in part to the same properties that make the metal an undesirable constituent of metallic zirconium.

To date nearly the entire supply of zirconium and hafnium has been produced at the Bureau of Mines Electrodevelopment Laboratory at Albany, Oreg. A commercial zirconium and hafnium metals plant is being constructed by Carborundum Metals, Inc., at Akron, N. Y., and completion is expected in July of this year. The company has a 5-year contract with the Atomic Energy Commission to deliver 150,000 pounds of zirconium and hafnium-sponge metal a year and will process zircon mined from Florida beach sands.

The availability of zirconium and hafnium metals for industrial application is limited by the existing production capacities, not by the available supply of zirconium ore.

USES

Zirconium has come to the attention of metallurgists and engineers recently as a structural metal having tremendous potentialities. Because of its high

resistance to heat and corrosion and because of special nuclear properties, zirconium is being used as a structural material for nuclear reactors and is playing an important part in harnessing atomic power. It also has great interest for engineers seeking a metal that can withstand the high temperatures in the combustion chambers of jet engines. The atomic-energy and national-defense programs are consuming almost the entire limited supply of zirconium; little has been available for experimental industrial applications. The most spectacular use of zircon (the principal source mineral of zirconium) during the past 2 years has been in the production of metallic zirconium, although only a small part of our zircon supply is used for metallic and alloying purposes. The estimated percentage distribution of zircon, by use, is as follows: Refractories, 45 percent; foundry facings, 19 percent; porcelain enamel, 7 percent; metals and alloys, 7 percent; pottery, 7 percent; electrical and chemical porcelain, 3 percent; glass, 1 percent; miscellaneous, 11 percent.

RESERVES

United States

Reserves of zircon in the United States are yielding more than enough to provide for demands due to the production of the coproducts—ilmenite, rutile, and monazite. Production of zircon in the past and at present is limited generally to the southeastern areas of the United States—North and South Carolina, and Florida. Extensive deposits exist in California, Idaho, and Oregon but must await either a nearby processing industry or development of coproducts for economic operation. These western deposits could be brought into production to satisfy the needs in case of emergency demand. Imports of zircon from Australia result from the coproduction of zircon and rutile and a tie-in with the imports of both ores.

Western Hemisphere

Brazilian baddeleyite deposits estimated at 2 million tons are being worked to produce concentrates containing 70 to 85 percent zirconium oxide. Beach sands containing zircon, monazite, and rutile are known to exist near Vitoria.

Deposits have been located in the Guianas and other Latin American countries but have not been developed.

PROBLEMS OF INDUSTRY

Zirconium and hafnium are classed as rare metals not because of their relative abundance in the earth's crust, but because of the difficulty in extracting the metals from their ores. The major problem of the metal industry is the production of sufficient ductile zirconium and hafnium to make their commercial utilization economically attractive.

The magnesium-reduction method, developed by the Bureau of Mines, for the production of ductile zirconium and hafnium is essentially a multistep batch process. Studies are being made to eliminate as many steps as possible in order to make the process continuous, which would aid materially in lowering the cost.

The defense effort has used the bulk of the ductile metal produced thus far; very little has been available to industry. The metals are known to have very attractive structural and corrosion-resistant properties. As production capacities and resultant supply are increased investigations must be conducted to develop new uses, especially in the metallic alloy field. The enormous available reserves of raw material assure an ample, continuing, supply for industrial expansion.

At present, less than 10 percent of the zircon production is consumed in metallic applications. Expanded, useful applications in the high-temperature refractory and ceramic field can be expected as a result of continued research.

The present markets for zircon are entirely in the East. Large zircon deposits in California, Oregon, and Idaho await development for lack of a western market. The establishment of zircon processing industries in the West appears to be attractive.

RECOMMENDATIONS

Research directed to produce lower production costs, and to devise a continuous metallurgical extraction process for both zirconium and hafnium should be continued for several years. The application of these metals in alloys and the physical characteristics of each of these products should be studied. Such a program would require a minimum of $200,000 annually.

RARE EARTHS

Mr. KLINE. I now want to discuss the rare earths. We use the term "rare earths" to cover some 16 different metals, because their names are long and difficult.

Senator MALONE. But you do have the names listed in the text?

Mr. KLINE. I have them here. The rare earth elements are in reality a closely related family, including such metals as lanthanum, yttrium cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutecium. Only within the past 2 years has it been possible to produce these individual elements in large enough quantities to supply a research program. Present production methods are neither adequate nor applicable for a large-scale operation. Before 1952 these metals were all recovered from one mineral, monazite. Before 1950, the United States depended virtually 100 percent upon imports from Brazil, India, and Malaya for its supply of the rare earth minerals. Monazite, a thorium rare earth phosphate, was the source material that was imported. Export restrictions were placed upon monazite by both India and Brazil mostly because of its fissionable thorium. These restrictions have cut United States imports to a very small fraction of what they were before 1950. Field investigations conducted by the Bureau of Mines in cooperation with the Atomic Energy Commission between 1948 and 1953 discovered a number of mineable deposits of alluvials containing monazite. In 1950, one of these deposits near Cascade, Idaho, was exploited by a private company and produced about one-third of our domestic requirements. Other companies began producing monazite from Idaho alluvials in 1951 and 1952. The output of monazite from dredge mining in Idaho, with a smaller amount recovered as a byproduct of ilmenite mining in Florida, can be expected to supply 60 percent of the present domestic peacetime demand. However, in case of war, the requirements for monazite may be 2 to 10 times greater.

Monazite domestic production and import statistics have been classified for security reasons.

Also another rare earth deposit has been discovered during that period of a mineral, bastnaesite, which previously had been of only academic interest.

Senator MALONE. I might say at this point, Mr. Kline, if it becomes necessary for any member of the committee to know more about these materials, we can get in touch with you and you can get clearance with regard to the classified information. However, we are particularly concerned with the availability of the raw materials from which these finished materials are made, that is, availability in the United States and the Western Hemisphere and the possibility under proper conditions of increasing our domestic production.

Mr. KLINE. This happens to be an instance where that could be done very easily.

Senator MALONE. If you will make it a part of the record I think that will be all that will be required.

Mr. KLINE. I think this points up one of the big arguments that we can discover new deposits all the time. We were believed to be absolutely without sufficient monazite to maintain an industry. We have definitely proved within the last 2 or 3 years that is not true. We have

ample reserves and the best evidence we have is that we are now producing for the first time in the history of the United States more than half of our requirements, and the first time in the history of the world by dredging rather than a hand operation.

Senator MALONE. You believe we could become self-sufficient if it is necessary or desirable, and the situation was pursued in a proper manner?

Mr. KLINE. That is correct. It is an example of what I pointed out in the original statement. In this field we have the obligation to establish an industry. That has been done. In the case of the Idaho monazite field, they started to dig with the old gold recovery equipment on it. We stayed with them for several months, worked with them, and helped them to devise beneficiation methods, studied suitable equipment, and encouraged them to improve recovery and they now have the latest type of monazite recovery equipment on these old boats.

Senator MALONE. I remember arguments on the Senate floor about monazite from India and from Russia and from sources which would be of doubtful availability in time of war. Therefore, one of the main objectives of this committee is to establish what the domestic industry is doing, and what it could do under proper conditions in the United States, and in the Western Hemisphere. Some of the statements that have been continually made over the last 20 years would almost make some of us break down and cry. We have lacked proof of what you are saying. That is where you come in.

Mr. KLINE. We have sufficient proof now.

Senator MALONE. Go ahead.

Mr. KLINE. A very large deposit of bastnaesite, a fluocarbonate of rare-earth metals containing very little fissionable thorium or uranium, was discovered and developed by the joint efforts of the Geological Survey, the Bureau of Mines, and the Molybdenum Corp. of America. This deposit, near Mountain Pass, Calif., began producing rare-earth concentrates in 1952.

Considering a gradually increasing demand for rare-earth materials the United States should be self-sufficient by 1954. However, new uses developed for the rare earths by industry and the military could create a demand far exceeding our potential output of monazite and bastnaesite.

Senator MALONE. You mean that if the demand were developed and the price was established so that a profit could be made you think that there might still be a shortage after a period of years?

Mr. KLINE. No, I mean with relation to our present output, not reserves. I am speaking of production capacity.

Senator MALONE. It will be necessary to enlarge our production and it can be enlarged if this demand develops.

Mr. KLINE. We have the reserves and the know-how now.

Senator MALONE. I would like to check all the crevasses and know where we stand in possible production in comparison to demand.

Mr. KLINE. One of the reasons that demand has been off has been because it has only been a year or two since we have been able to extract these sixteen individual elements in sufficient quantity to even experiment with them and study their uses. We do not know just what they will all do yet.

Senator MALONE. It is an entirely new field.

Mr. KLINE. Absolutely.

Senator MALONE. And you are in the forefront of this investigation. As far as you know, in the world?

Mr. KLINE. That is correct. You probably will be interested to know—I am sure you do know—we have a new station in construction in Reno, and the purpose of that station will be largely devoted to research in the rare metals field.

Senator MALONE. I am glad to know that the emphasis is being put on these rare materials. I was supposed to help dedicate that building and a Democratic horse fell with me in Pennsylvania, and I had to make new arrangements.

Mr. KLINE. Outside of the United States reserves of monazite and other source minerals for recovery of rare-earth minerals have not been measured, but occurrences are known in virtually every area of the world. India, Brazil, and the United States are virtually the only countries having appreciable recorded production and exports from these areas are now under Government control.

Senator MALONE. But we have plenty for our own use in your opinion, if we proceed in the manner you suggest?

Mr. KLINE. Yes, I think so. There are ample reserves of monazite in the Western Hemisphere for the predictable future, and adequate reserves in the United States for an emergency. More details on reserves are included in the supplementary statement. These rare earths have many important uses. I have listed a few here. They are used for high luminosity carbon electrodes, special alloys with magnesium and aluminum used in jets; as scavengers for steel and as an alloy in cast iron and stainless steel. They are used for a glass decolorizer, glass additive to cut out ultraviolet light, and as a glass polisher. It can be used for waterproofing and as fungicide agents, for tanning leather, dyeing and printing, and in explosive production, and as a catalyst.

Senator MALONE. All this is explained in some detail in your statement?

Mr. KLINE. We have that in the more lengthy statement; yes. The substitutes known to date are few. The only one that really seems to be suitable in even a few instances is selenium. Of course, selenium is scarcer than almost any rare metal we have. Our first recommendation is again an established stockpile in case of an emergency until our own industry gets on its feet.

The second recommendation we have is a continuing policy for domestic producers by which we mean a definite policy regarding imports and prices. We also need a definite policy regarding the use of thorium in atomic energy.

The other recommendation, of course, is to improve ore-dressing techniques on bastnaesite recovery and develop methods to separate the individual rare-earth metals from the group in large quantities by inexpensive methods such as liquid-liquid extraction.

Senator MALONE. Take your reference to monazite and bastnaesite; could you state which is the most desirable or less expensive? What is the difference in their use?

Mr. KLINE. I am a monazite man. I am strong for monazite. The reasons are that from a mining standpoint you cannot mine cheaper than by dredging.

Senator MALONE. It is a matter of cost?

Mr. KLINE. Yes.

Senator MALONE. Either can be used?

Mr. KLINE. When you mine bastnaesite, you have a higher mining cost, and the material still has to be milled.

Senator MALONE. It is a ledge material?

Mr. KLINE. Yes. The beneficiation process is not too successful, and it is costly. Even when perfected it will cost a lot of money. When you produce your final concentrate it may run 50 percent combined rare earth. When you take your monazite concentrate off the dredge and then run it through a magnetic separation plant, you have a concentrate that contains 70 percent of rare earths. And all those materials have to be shipped.

Senator MALONE. That is very good.

Mr. KLINE. Monazite has thorium. We think that is very important. Bastnaesite has not.

Senator MALONE. That is true. You mentioned that a principle must be laid down as far as imports are concerned, in line with a policy of equalizing domestic production with foreign production. You have heard the testimony here—and almost every industry is in the same category—that there would have to be laid down by Congress a fair-trade policy. That is some differential that would even the difference in the production cost of domestic and the foreign production. In general, such a differential would make up the difference between the wage standard of living here and abroad, and assure a continuance of the domestic industry. Did you have something of that nature in mind?

Mr. KLINE. This is an excellent example, Senator. In 1951 when the first monazite came into production in Idaho, I think we had about 2-month stock of monazite reserves in the United States, and Brazil and India had cut off all supply.

Senator MALONE. They were not producing?

Mr. KLINE. They were not producing in the States. The foreign countries were producing, but would not ship because of the thorium content.

Senator MALONE. They refused to ship to the United States?

Mr. KLINE. They refused to ship to the United States.

Senator MALONE. It was an absolute refusal?

Mr. KLINE. Absolutely; it was by law.

Senator MALONE. As a matter of fact, could that not happen with any material at any time with foreign nations over which we have no real control?

Mr. KLINE. It is certain to occur in any mineral that contains fissionable materials, which is the case with monazite. I think nearly every foreign producer has a restriction of one type or another.

Senator MALONE. Are you familiar with the difference in cost of monazite? Can it be imported at a lower cost.

Mr. KLINE. It has been as low as $50 a ton. Before the embargo I think it was $200 a ton. When everybody was scared to death in the United States, they contracted with the dredge operators in Idaho for $375 a ton, and they gave them a 5-year contract which has run going on 3 years. The boys out there operating are scared to death because in the meantime we have even gone so far as to make contracts to receive monazite from Africa.

Senator MALONE. At what price?

Mr. KLINE. I think it is around $300 a ton. The peculiar part of this situation is that we were called into this field not because there was a shortage of monazite reserves in the world, but because they thought we did not have any. Then we discovered that we have an adequate supply here in the United States, and in the face of that, people go out and make a contract in Africa, which puts us back exactly in the same spot that we were when we went into the field.

Senator MALONE. You are in just about the same spot as zinc and lead producers.

Mr. KLINE. So far as monazite is concerned, that is correct.

Senator MALONE. In other words, it is just a question of whether or not we want to produce in this country.

Mr. KLINE. That is certainly true.

Senator MALONE. If we do want to, then Congress must lay down some principle.

Mr. KLINE. That is right. If these people can be assured that they are not going to be run out for a year or two by a foreign producer, they can continue to operate.

I would like, if possible, to make one more statement regarding monazite production in Idaho, if that could be placed back in the record before we finish the testimony on rare earths. I would like to point out that in addition to those items that have already been mentioned, one of the things that is needed more than anything else to guarantee us a long-lived industry that can stand on its own feet in the United States and withstand the foreign competition is the use of the byproduct minerals that are now recovered from dredging for monazite.

Among the most interesting of these minerals are ilmenite and zircon. From the earlier testimony you can see the significance of these two minerals. We are producing ilmenite as a byproduct of dredging at the rate of 100 tons a day, and the mineral is presently being stockpiled and held because it has no use. It will not bear the freight necessary to ship it to the proper point.

In view of the fact that we have this titanium plant at Henderson, Nev., it looks like it might be well worth spending considerable sums in research to convert the ilmenite into a material that will be suitable for the manufacture of titanium to replace rutile, which is now the source of our titanium metal. Its proximity, its high grade and abundance, recommends its consideration for that purpose. The same can be said about zircon, which is produced in great amounts and is the source mineral for zirconium production.

If the operators could receive some recompense for these two minerals in addition to the monazite they are producing, they could very easily stand on their own feet.

Senator MALONE. That is a very clear statement, and it makes the whole operation very clear. Do you have another statement?

Mr. KLINE. We have a longer statement on rare earths.

Senator MALONE. This is more detail on the rare earths you have described already?

Mr. KLINE. That is right. It covers the same field but in more detail.

Senator MALONE. You have no charts connected with this material?

Mr. KLINE. No.

Senator MALONE. This statement will be accepted and appear at this point in the record as part of Mr. Kline's testimony.

(The information is as follows:)

RARE-EARTH METALS

The rare earths are neither rare nor earths; nevertheless this closely related family of 16 metals (lanthanum, yttrium, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium) excites the interest of the research metallurgist with a fascinating field for investigating their properties and their applications in industry. Only within the past 2 years has it been possible to produce these elements in quantities sufficient to consider undertaking such a research program. Even at present, the production methods are not adequate nor applicable to large-scale operations but must be developed rapidly in order to keep pace with the new defense uses that are being suggested for these intriguing metals.

Between 1910 and 1950 the United States was dependent entirely upon foreign sources for the rare-earth elements.

The recent discovery of large domestic reserves of monazite and bastnaesite has made the United States, at last, partially self-sufficient and able to supply from these minerals the Nation's immediate need for the rare-earth metals which are highly important to industry and the defense program.

Monazite, a rare-earth phosphate containing thorium, is presently the most important commercial source of these metals. The recent discovery in California of a very large deposit of bastnaesite, a fluocarbonate of the rare-earth metals, has added another commercial source to the United States supply. Bastnaesite, however, contains little, if any, thorium. Monazite usually is found as a constituent of beach or placer sands. Bastnaesite is found generally in lode deposits.

The Bureau of Mines has played a significant part in the recent aggressive investigation of domestic monazite reserves. Under contract with the Atomic Energy Commission, the Bureau of Mines examined potential sources of monazite in North and South Carolina, Montana, Idaho, Wyoming, and California. As a result of this work, adequate strategic reserves of monazite for the immediate future have been indicated in Idaho. Promising deposits have also been found in South Carolina. The Bureau of Mines' work in delineating the reserves of titanium minerals in central and northeastern Florida also contributed indirectly to this investigation because estimates of monazite concentration were made during the testing.

The possibility of there eventually being a use for thorium as a source of atomic energy prompted India, in 1946, and Brazil, in late 1950, to place an embargo on exports of monazite concentrates.

USES

The rare-earth metals extracted from the rare-earth minerals are consumed principally for the following purposes: Carbon arc electrode cores, 50 percent; misch metal and ferrocerium, 25 percent; and miscellaneous, 25 percent.

The principal nonenergy uses of thorium and its compounds are in the manufacture of gas mantles, refractories, and polishing compounds, in the production of various chemical and medical supplies, and in the electrical industry in the manufacture of lamp filaments and vacuum tubes.

The use of thorium as a possible source of energy depends on the fact that when thorium-232, the naturally occurring isotope of the element, is subjected to bombardment by neutrons it is converted into fissionable uranium-233 in a quantity exceeding the original quantity of uranium-233, uranium-235, or plutonium-239 consumed in providing the necessary stream of neutrons. This operation of creating an excess of nuclear fuel is known as breeding.

It would seem reasonable to assume that thorium will, in due course, be an outstanding source of energy and that the current importance attached to it as a possible source of fissionable material is well warranted.

Misch metal, the mixture of all the rare-earth elements in metallic form, contains between 45 and 55 percent cerium; because of the predominating constituent, the mixture is often referred to as cerium. Misch metal has been alloyed with copper, nickel, zinc, aluminum, and magnesium. Some of these alloys are important in the construction of aircraft, jet engines, and gas turbines.

RESOURCES

Large productive deposits of monazite occur in the states of Travancore, India; and Rio de Janeiro, Espirito Santo, and Bahia in Brazil. Smaller but significant deposits are known in Australia, Argentina, Ceylon, United States of Indonesia, Korea, and the Malayan Union. In the United States large reserves of monazite have been discovered recently by the Bureau of Mines in the placer gravels of central Idaho, along the flanks of the Idaho batholith. Other deposits are known in Florida, North and South Carolina, and California. Deposits of commercial quantities of bastenaesite occur in the Belgian Congo (Ruanda-Urundi), California, and New Mexico. Small production of allanite and cerite has been reported from Sweden and the United States.

The possibility of eventually using thorium as a source of atomic energy prompted India, in 1946, to place an embargo on exports of monazite concentrates. The embargo has remained in effect since that time, effectively cutting off one of the most important raw material sources for the industry of the United States. Brazil increased its production and from 1946 until about August 1950 was practically the sole source of United States imports. This favorable position enjoyed by Brazil has, in part, made possible an increase of about 500 percent in the price of monazite concentrates. Brazil has temporarily (since January 1, 1951) suspended the issuance of export licenses for monazite. A provision is made to export the material on a Government-to-Government basis if its need for military requirements can be firmly stated. The Government of India and Brazil have been receptive to offers from foreign commercial firms who would agree to construct and operate monazite processing plants within the confines of the monazite producing country. Under this type of agreement, the processor would market the rare-earth content, leaving the thorium for stockpiling in the country of origin. A French firm, the Societe de Produits Chemiques des Terres Rares, has made arrangements with India to provide capital and technical skill for the establishment and operation of a monazite processing plant in that country. Another French country, probably affiliated with the first, has discussed the possibility of a similar arrangement with the Government of Brazil. Exportation of monazite from Australia to nonempire destinations has been forbidden since 1944. American capital is expected to provide for an ilmenite recovery operation at Trincomalee, Ceylon, from which monazite probably will be produced as a coproduct. A few tons of monazite are being produced annually from sands of the Nile delta in Egypt. The United Kingdom Ministry of Supply is attempting to encourage recovery of monazite as a byproduct of Nigerian tin output. Arrangements have been made with the Anglo-American Corp. of South Africa for large shipments of monazite to the United States over a 3-year period.

California bastnaesite

The Molybdenum Corp. of America owns most of the claims to the massive barite-carbonate-bastnaesite lode in the Mountain Pass area of San Bernardino County, Calif. This deposit of bastnaesite, a fluocarbonate of rare-earth metals, was discovered in April 1949. The mineral was identified by a Bureau of Mines mineralogist attached to the Boulder City, Nev., station. The main ore body is about 2 500 feet long and 500 feet wide. There is a tremendous tonnage available; it has been estimated conservatively to average between 5 and 10 percent total rare-earth oxides.

Difficulties are being encountered in concentrating the rare-earth mineral. The intimate association of the barite and bastnaesite combined with the tendency of the ore to slime upon grinding have contributed to the recovery difficulties. The present practice is to float the barite away from the other minerals and, after conditioning the tailing from this step, float the bastnaesite. Three rare-earth-containing products result and of necessity must be processed further. The barite concentrate contains about 9 percent total rare earths; the bastnaesite concentrate contains about 38 percent rare earths and 18 percent barite; and the tailings contain about 13 percent rare earths and 21 percent barite. Present practice is to digest the bastnaesite concentrate in hydrochloric acid to remove most of the calcite and then ignite to drive off water of crystallization; this results in a product containing about 50 percent total rare earths, which is shipped to the national stockpile. Eventually the other products will be treated in the chemical plant to yield marketable barite concentrates and rare-earth oxides.

Idaho monazite

The earliest attempt to produce monazite in Idaho was in 1909 when a small plant was built near Centerville in the Boise Basin. The plant was abandoned after a few months as it could not compete with low-cost monazite from India.

Between 1946 and 1948, the gold-dredge operators in the Boise Basin saved some of the monazite-bearing black sands but made no attempt to separate the rare-earth minerals.

In 1949 the Bureau of Mines began a series of churn-drill investigations to ascertain the monazite tenor of the alluvial deposits along the flanks of the granitic mass called the Idaho batholith. The first work was conducted in areas where monazite was known to occur, and one of these was the Boise Basin. Preliminary studies indicated that higher concentrations of monazite existed in the alluvials in areas not previously reported to contain the mineral.

The Big Creek deposit near Cascade, Idaho, was among the many alluvial deposits examined from 1949 through 1952. A gold dredge, with minor flow-sheet alterations for saving the black sands and monazite, was placed on the Big Creek deposit in December 1950. This dredge, owned by Baumhoff-Marshall, Inc., began mining the alluvials early in January of 1951. Monazite is the sole source of revenue as only a trace of gold is present in the gravels, and the other black sands presently have no value in Idaho. At the present time two dredges are producing nearly one-half the current domestic needs for monazite.

The sands and gravels are dug by an endless bucket line and washed and screened in a revolving trommel with ¼-inch perforated openings. These fines are distributed over large rougher jigs to produce a concentrate running about 40 to 50 percent black sands. This product is then sent to cleaner jigs to be upgraded to over 96 percent black sands.

The final concentrate is pumped ashore into trucks which haul it to the railroad where it is transported to the separation plant at Boise, Idaho. There the sands are dried in a revolving kiln and sent to high-intensity separators and magnetic separators to remove the ilmenite, garnet, magnetite, zircon, and a small quantity of quartz-feldspars. The clean monazite is bagged and shipped to the industry's processors, who treat the monazite and reduce it to the various rare-earth salts for marketing.

SUBSTITUTES

Most of the carbon arc electrodes containing rare-earth cores are consumed by the motion-picture industry as a light source in film projectors, a substantial quantity of misch metal is used in the form of ferrocerium alloy for flints in mechanical lighters; and a large portion of the rare earths consumed in glass manufacture is used for decolorizing glass batches made from inferior grades of sand high in iron. In a period of emergency, all of the foregoing uses could be termed nonessential. In each case, substitute materials are available which are comparable, and cost less, but they are less satisfactory than the rare-earth metals. The substitute materials in question would not entail the use of other strategic items except in negligible quantities.

Rare-earth compounds are superior to any other for carbon arc electrode cores; however, there are many more common, less expensive, materials which can be substituted. In all cases substitution is accompanied by a loss in light emission efficiency. Iron and calcium fluoride may be used but with a 30-percent reduction in light intensity. These electrodes are not objectionable for projection of black and white pictures, but the light is not white enough for the completely satisfactory projection of color pictures.

Zirconium-impregnated lead flints probably could replace ferrocerium completely during an emergency. The substitute flint might be more expensive and probably less satisfactory.

White arsenic is a satisfactory substitute for rare-earth compounds used in decolorizing glass batches. Rare-earth compounds have no known substitute in the production of special glasses possessing ultraviolet absorptive properties or unusual optical characteristics which make them desirable for strategic purposes. Rare-earth oxides could be replaced by rouge, a less expensive and less strategic compound, for polishing glass and metal. However, it is generally conceded that the rare-earth oxides are so superior for this application that this use is rated almost strategic.

If conditions would demand it, some rare-earth compounds could be recovered by collecting the unburned electrode stubs and the dense white oxides that result from burning the cored electrodes. Some of the rare-earth oxide could be recovered also from glass polishing operations.

No real substitute for thorium exists as a source of atomic energy other than uranium, and of course that metal is not available to industry.

PROBLEMS OF THE INDUSTRY

Of primary importance to industry and the Government is the need to define large reserves of monazite within the continental United States. Foreign sources of supply often prove to be undependable in time of emergency because of transportation difficulties. In addition, foreign countries are reluctant to deplete their own highly strategic natural resources for the benefit of other nations.

The concentration and separation of monazite and bastnaesite from the associated minerals or gangue continues to be a difficult problem. Work completed to date on monazite beneficiation indicates that an overall recovery of about 80 percent of the monazite can be made in mining the domestic placers and the subsequent separation of the minerals from the heavy, or black-sand, concentrates. If another 10 percent of the monazite could be recovered, lower grade alluvials could be mined. The recovery of fine particle size bastnaesite from complex gangue materials is even more difficult, resulting in unsatisfactory low recovery of the mineral by present ore-dressing and metallurgical processes.

The initial cost of installation of a large dredge to mine monazite from stream gravels may run from one to several million dollars. Mining companies are reluctant to make such investment in the absence of an assured market for thorium or for the rare-earth metals contained in monazite. Some processors of monazite will offer contracts to mining companies for a monazite product based upon the rare-earth content. However, these operators cannot depend on a contract price for the thorium until such time as the AEC has established a policy regarding the purchase of this metal or its salts.

Two of the most pressing problems of the industry are: (1) The uncertainty regarding the price for the domestic production for monazite and the threat of flooding the market with foreign production, and (2) to establish markets for the accessory heavy minerals which are being mined with monazite. The rutile, ilmenite, zircon, and garnet could pay a large part of the cost of a mining operation.

RECOMMENDATIONS

1. A stockpile for a 5-year emergency.

2. Continue the search in the stream systems of the United States to outline promising placer deposits containing appreciable quantities of monazite, with consideration given to accessory minerals such as rutile, ilmenite, zircon, and garnet for their potential marketable values that could contribute toward successful exploitation of the deposits by industry.

3. Develop marketing patterns permitting disposal of the heavy accessory minerals which are recovered in the mining of monazite-bearing gravels.

4. Continue beneficiation studies so as to develop new and better methods and equipment to obtain a higher recovery of the monazite and other important heavy minerals in mining beneficiation and the extraction of the rare metals from their source minerals.

5. The treatment and separation of the fine-particle size bastnaesite from the complex gangue minerals warrants extensive study.

6. Research studies will be made to separate the individual elements contained in the rare-earth minerals of monazite and bastnaesite.

7. Further, research will be started in the steel and alloy field to determine the value of each and every rare-earth element as component parts of new alloys to develop better materials for the use of our civilian and military requirements.

Most of the objectives of this program could be attained if $250,000 were available to finance the proposed field work and laboratory research. This sum could most advantageously be spent if it were allotted in equal amounts over a period of 3 years.

SELENIUM

Mr. KLINE. The next element I wish to talk about is selenium.

Senator MALONE. Is that the last one?

Mr. KLINE. We can cut it off there.

Senator MALONE. And submit it for the record.

Mr. KLINE. The only commercial source of selenium at present is the anode mud or slime produced in the electrolytic refining of blister copper. Selenium content of blister copper anodes handled by do-

mestic refineries ranges from 0.03 to 0.14 percent; the slimes generally contain 8 to 9 percent selenium. Metallurgical treatment of the slimes involves three steps, the first for the removal of the contained copper, the second for removal of selenium, and the third for the removal of tellurium.

Production in 1952 was 687,000 pounds. Consumption was over 800,000 pounds. Canada produces about as much as we do, but the United States imports declined to 132,000 pounds in 1952, and will probably decline even further in 1953. Stocks on hand have declined from 266,000 pounds in 1949 to practically nil at the present time. It is used for power rectifiers, for the decolorization of glass, as a catalyst, stainless steel, pigments and medicine.

Substitutes within limits are germanium in rectifiers, manganese in glass, tellurium in rubber and steel.

Recommendations: It is strongly recommended that we maintain a 5-year stockpile of selenium metal to meet defense requirements. Within five years we can do nothing to lessen the danger of being caught short in this important commodity.

Second, a long range program should be started for the recovery of selenium from seleniferous soils, tuffs, and plants. An immediate study of the possible substitution of silicon rectifiers for selenium rectifiers should be made. An investigation of new sources of selenium should be initiated and continuous research for the development of metallurgical processes for the extraction of selenium from low grade ores should be undertaken.

Here is a statement I would like to submit for the record, Senator.

Senator MALONE. I would like to ask you, Mr. Kline, if in these more complete statements of the materials you have discussed, the present demand in pounds or tons and value is set down, and some estimate made of the future amounts which will be necessary?

Mr. KLINE. Where that material has been released, we have done so.

Senator MALONE. Then this statement on selenium will be accepted, and appear in the record at this point as a part of Mr. Kline's testimony.

(The information is as follows:)

SELENIUM

Impetus was given to the progress of electronics by the development of the diminutive selenium rectifier. Used in voltage multiplier circuits for radio and television sets, the selenium rectifier eliminates the use of bulky transformers and rectifier tubes. These recent developments suggest new fields for research in the use of selenium and also promise expanding demand with attendant need for new sources of supply.

The only commercial source of selenium at present is the anode mud or slime produced in the electrolytic refining of blister copper. Selenium content of blister copper anodes handled by domestic refineries ranges from 0.03 to 0.14 percent; the slimes generally contain 8 to 9 percent selenium. Metallurgical treatment of the slimes involves three steps, the first for the removal of contained copper, the second for removal of selenium, and the third for removal of tellurium.

RESERVES

Domestic production of selenium in the 5-year period, 1947–51, averaged 514,988 pounds annually and was produced by 3 companies: American Smelting & Refining Co., U. S. Metals Refining Co. (subsidiary of American Metal Co., Ltd.), and International Smelting & Refining Co. Selenium production in the United States was 687,384 pounds in 1952, and a production of nearly 800,000 pounds for 1953 is indicated.

Apparent domestic consumption of selenium during the 5-year period ranged from about 600,000 pounds to more than 1,000,000 pounds annually, averaging 848,460 pounds. Producers' shipments averaged 536,215 pounds; imports to consumers, 312,245 pounds; and exports 27,321 pounds. Over 800,000 pounds of selenium were consumed in the United States during 1952. Demand existed for larger quantities of selenium than were available.

The National Production Authority placed both imported and domestically produced selenium under complete allocation toward the close of 1951, explaining that the action was necessary if essential defense requirements were to be met. Allocation was terminated in early 1953, but the shortage continues.

The outlook is not favorable under a continuation of existing circumstances for obtaining increased supplies of selenium from the usual sources, to meet expanding current requirements and to provide for full mobilization needs.

South America

Chile ranks second only to the United States as a copper producer, but apparently produces no selenium or commercial products from which selenium is recovered in substantial amounts. A good deal of Chilean copper is still recovered by electrolysis of leach solutions, with the result that the selenium contents of the ores treated are not recovered and probably could not be recovered economically. Although substantial tonnage of oxide ore still remain, an increasing proportion of the total copper output is coming from sulfide ores which have to be smelted. The resulting matte is converted into blister copper, but a good deal of this copper at present is sold as "furnace refined." No data have been obtained as to the selenium contents of sulfide ores at the principal mines, or as to selenium losses in smelting and converting, but the selenium content of the blister copper is believed to be characteristically low. However, this subject should be investigated further, although no steps are known to be contemplated for developing commercial selenium supplies in Chile, except insofar as Chilean blister may come to United States plants for refining. There is an electrolytic refinery in Peru, but no information has been obtained as to potential selenium production there by the Cerro de Pasco Co.

Africa

Northern Rhodesia and the Belgian Congo are also major producers of copper, but available analyses of the blister copper indicate that it is remarkably low in selenium. Northern Rhodesia does produce about 6 tons of selenium a year despite low percentages. Australia produces about 2 tons per year.

Canada

Selenium is produced in Canada by the International Nickel Co. at Copper Cliff, Ontario, and by Canadian Copper Refiners, Ltd. Montreal East, Quebec. The latter plant, which treats blister copper produced by Noranda Mines, Ltd., and by Hudson Bay Mining & Smelting Co., has a rated annual production capacity of 450,000 pounds of selenium, but its 1950 output was less than 350,000 pounds, after declining gradually from its peak output of 521,867 pounds in 1946. This decline reflects the reduction in output of selenium-rich high-grade ores from the Horne Mines at Noranda, and a larger proportion of copper obtained from other mines. However, even the Hudson Bay blister is unusually high in seleium, available analyses showing 0.18 percent of this element.

USES

Commercial uses for selenium began to develop on a substantial scale during the interwar period in the glass, ceramic, chemical pigment, and rubber industries, and later in the stainless steel industry. Selenium rectifiers, for the conversion of alternating current to direct current, were used industrially for many years but only on a small scale. In 1947, the minature-type selenium rectifier for electronic circuits was developed. These diminutive rectifiers, as employed in voltage multiplier circuits for radio and television sets, eliminate heavy and bulky transformers and rectifier tubes. Military uses of the selenium rectifier cover a wide range of applications.

Selenium is used in the glass industry as a decolorizer, and in the stainless steel industry as an additive to improve machinability and to control the quality of castings. A diversified group of chemical uses, including pigments and rubber accelerators, now outranks both the glass industry and the steel industry in the use of selenium.

SUBSTITUTES

Germanium, silicon, titanium dioxide, and other semiconductors can replace selenium in a few types of rectifiers. Manganese can be used to decolorize glass. Gold and copper can impart a red color to glass. Tellurium can substitute for selenium in some types of stainless steel and rubber.

PROBLEMS OF THE INDUSTRY

The overall problem associated with selenium is twofold: (1) defining the field of near-future application in electronics and other industries of selenium, and (2) substantially expanding the domestic supply of selenium.

RECOMMENDATIONS

The problem of increasing the selenium content of blister copper anodes and the problem of developing new sources, such as in the nonferrous metal smelting industries, in uranium-vanadium plants, iron blast furnace flue dust, sulfuric acid plants, and other industrial plant waste have been under investigation at the Salt Lake Experiment Station of the Bureau for about a year. Many data have been developed, and further investigations are in progress under the project.

Seleniferous soils and tuffs occur in the general vicinity of Thermopolis, Wyo., that are reported to contain as much as 0.05 percent water-soluble selenium in beds 40 to 60 feet thick. Certain plants in the area take up selenium from the soil. The problem of recovering selenium economically from the tuffs and from the ashes of the plants has been suggested as warranting investigation. A tuff deposit at Lysite, Wyo., has a selenium content of 15 million pounds in that portion exposed at the surface.

A long-range program might well be directed toward the recovery of selenium from seleniferous soils, tuffs, and plants; an emergency program toward the possible substitution of silicon rectifiers for selenium rectifiers and an immediate program toward (1) a continuation of the investigation of new sources of selenium in progress at the Salt Lake Experiment Station, (2) an economic study of the availability of selenium in the United States and foreign countries, and (3) a continuous study of developments in the electronics and associated industries, (4) developing metallurgical processes for the extraction of selenium from low-grade seleniferous materials.

Senator MALONE. At some reasonably future time we might request from you a display of some of these short-cutting methods for the benefit of the committee, and for anyone else who would care to observe it.

Mr. KLINE. Selenium offers a distinct problem. In fact, it occurs in such minute quantities there is no such thing as an economic deposit of it. The selenium occurs in the soil in the order of 100 to 150 parts per million. These seleniferous tuffs in the western country grow a special kind of weed which concentrates the selenium within the plant which then becomes poisonous and if eaten will kill cattle or livestock. Strange as it seems, we have a project in mind for growing these weeds, and recovering the selenium they concentrate.

Senator MALONE. There is not a possibility that if you established this weed that it would spread?

Mr. KLINE. Yes, there is. That is something we worry about.

Senator MALONE. You will take it up with me I hope before you put that project in Nevada.

Mr. KLINE. Very well.

Senator MALONE. I understand your position thoroughly. You have been a very valuable witness to this committee. Would you keep in mind that the committee might be interested in a display.

Mr. KLINE. Such a thing can be provided.

Senator MALONE. If you do that, we can use it.

Mr. KLINE. Senator, we did not cover all the metals because of the great number. I have two other statements and still a few more I would like to submit at a later date.

Senator MALONE. All right. The statement on germanium and tellurium will be accepted and appear at this point in the record as a part of Mr. Kline's testimony.

(The information is as follows:)

GERMANIUM

Born of research begun in World War II, germanium semiconductor devices are implementing a revolution in electronics that is destined to give the metal a new economic stature and remove it from the category of the "rare" mineral commodities.

SUMMARY

The principal domestic source of germanium is the zinc sulfide (sphalerite) concentrate produced in the tri-State lead-zinc mining district of Missouri, Kansas, and Oklahoma. The concentrate contains about 60 percent zinc and from 0.01 to 0.1 percent germanium.

In the metallurgical recovery of the germanium the concentrate is roasted, which operation drives off the sulfur and converts the zinc, germanium, and cadmium in the concentrate to the oxides of the respective metals. The oxides, with the addition of coal and salt (NaCl), are sintered at high temperature, and the germanium and cadmium oxides changing to chlorides of the two metals are volatilized. Both the germanium and cadmium fumes are condensed and collected by passing them through an electrostatic precipitator. The germanium, in the form of germanium tetrachloride, is hydrolyzed in ice water to obtain pure germanium oxide which, in turn, is reduced to the metal by heating in hydrogen.

Domestic production of germanium on an industrial basis may be said to have begun in 1942 when the Eagle-Picher Co. erected a germanium-recovery plant at its Henryetta zinc smelter. Consumption of germanium over the period 1942–51 has about paralleled reported production.

The principal use of germanium is in the field of electronics by virtue of its being a semiconductor. Germanium diodes and transistors, which can perform almost every function fulfilled by the vacuum tube, are smaller, lighter, and potentially cheaper than their tube counterparts. They require no hot filament or hot cathodes, hence require much less power to operate, and have apparently an indefinitely long life. To their development is due the much heralded "revolution in electronics."

Current and estimated near-future supplies of germanium would appear to be ample for both immediate requirements for the metal and the early requirements resulting from new applications in the field of electronics. Estimated near-future supplies fall short of meeting full-mobilization requirements.

A long-range program for the Bureau should be directed toward the determination of new domestic sources of germanium including coal; an emergency program toward the determination of new domestic sources of germanium other than coal; and an immediate program toward (1) determination of germanium reserves in the tri-State district, (2) development of analytical methods for germanium, (3) increasing metallurgical recovery of germanium from zinc concentrates and effecting recovery of germanium from foreign copper-lead concentrate, and (4) continuous study of electronic developments.

PRODUCTION AND CONSUMPTION

Domestic production of germanium on an industrial basis may be said to have begun in 1942. That year the Eagle-Picher Co. erected a pilot plant at its Henryetta, Okla., zinc smelter for the treatment of cadmium byproducts and produced a small quantity of germanium metal, oxide, and chloride. Total shipments during the year represented less than 10 pounds of metal, and in its annual report for 1942 to the Bureau of Mines the company stated: "The germanium which we have sold, in addition to a large number of samples furnished by us, has been used by several universities and manufacturing concerns for a purpose of which we are not informed. It is our understanding

that the work is being done at the direction of the Army and Navy, but we have been asked not to disclose the names of the users."

Through the 3-year period 1943–45 the domestic output of germanium continued at less than 100 pounds annually, with the Eagle-Picher Co. the sole producer. In 1946 production in the United States reached a level of several hundred pounds, and output has since increased each year over the preceding year with the annual increase ranging from 28 to 140 percent.

A recent survey by the Bureau of Mines indicates a production of 10 tons of germanium dioxide in 1953, 20 tons in 1954, and 30 tons in 1955.

Until 1948 the Eagle-Picher Co. was the only domestic producer of germanium; beginning with that year the American Steel & Wire Co. (subsidiary of the United States Steel Corp.) has annually produced a comparatively small qauntity of germanium dioxide at its Donora, Pa., smelter. In 1949 the National Zinc Co. also produced a small quantity of germanium dioxide at its Bartlesville, Okla., smelter but in 1950 and 1951 reported no production. Production at this plant was resumed in 1952. American Zinc, Lead & Smelting Co. placed their Fairmont City germanium recovery unit in operation on December 18, 1952. Sylvania began germanium production at Towanda, Pa., early in 1953. American Smelting & Refining Co. started germanium recovery operations at their Corpus Christie plant in 1953. Matthiessen & Hegeler Zinc Co. expect to produce germanium in 1954. Metallo-Chemical Corp. produced some germanium tetrachloride in 1952 but has discontinued production. Anaconda Copper Mining Co. is initiating germanium recovery at Great Falls, Mont. In August 1953 Eagle-Picher placed its new germanium plant at Miami, Okla., into operation. In the years 1948 to 1952, inclusive, the Eagle-Picher Co. has annually accounted for more than 90 percent of the germanium produced.

PRICES

As recently as 1940 germanium was a really rare metal and priced at $4,500 a pound or $308.56 a troy ounce—nearly 9 times the price of gold.

In October 1952 germanium metal was quoted at $340 per pound and germanium oxide at $142 per pound. On August 15, 1953, Eagle-Picher lowered the price of metal to 65 cents per gram ($295 per pound) but did not alter the price of germanium dioxide.

USES

A number of uses had been suggested for germanium by 1930, but up to that time no outstanding advantages had been demonstrated that seemed to make germanium better suited for those uses than other lower-priced and more abundant materials. None of the uses developed for germanium appeared sufficiently promising to the War Production Board in 1942 to induce that agency to stimulate domestic production. Use of germanium as a catalyst in the hydrogenation of coal was reported in 1943, and as a refractive element in optical glass and an alloying element with magnesium, aluminum, gold, and platinum in 1945.

Small quantities of germanium are consumed as magnesium germanate for use as a phosphor in fluorescent lighting and color television tubes. The most recent application of germanium is as a carrier for radioactive phosphorus in cancer treatment.

As already indicated under "Production and consumption," the Eagle-Picher Co. reported as early as 1942 that it was furnishing germanium to several universities and manufacturing concerns for use in connection with work for the Army and Navy. In the light of developments since then, an assumption would seem reasonable that research investigation of the use of germanium in the field of electronics was well underway at that time. Rapid progress, probably attributable to the urgency involved under World War II requirements, must have been achieved in the investigations inasmuch as the principal use of germanium in 1945 was reported to have been in radionic devices.

The use of germanium in the field of electronics is by virtue of its being a semiconductor. At this point the question may well be asked: What is a semiconductor? An answer to the question requires a bit of explaining, as follows:

Whether a solid will conduct electricity depends on the degree of freedom of its electrons. Copper, a good conductor, has a single electron in its outer orbit or shell, and this relatively free electron readily serves to carry current. Most metals have such loosely held electrons, hence are good conductors. On the other hand, an element such as sulfur, whose electrons are all locked in place by tight bonds with the nucleus and with other atoms, does not conduct electricity; is is an insulator.

Between these extremes there is a class of materials known as semiconductors which furnish an occasional free electron for carrying current. Silicon and germanium are examples; they have about 1 free electron for every thousand atoms (as contrasted with copper, which has 1 for every atom). These semiconductors have long possessed a special interest for electronic researchers. The important fact about them is that the number of current-carrying electrons in them can be controlled. They can be made to act as conductors under some conditions and as insulators under others. Indeed, they are so sensitive that the current flowing in a semiconductor can be controlled by the brightness of a light shining on it in a region where a fine wire touches it. So this class of materials has been adapted to many uses. The crystal detector, used in early radios and now employed in an improved form in radar sets, is a semiconductor.

In the field of electronics germanium is used principally in what are known as diodes and transistors which, according to a recent statement, can achieve almost every function fulfilled by the vacuum tube. Germanium diodes and transistors are tube counterparts. They require no hot filment or hot cathode, hence require much less power to operate, have apparently an indefinitely long life, and are shock resistant, an essential characteristic for use in projectiles. To their development is due the much heralded "revolution in electronics."

The diodes and transistors on the market at present are known as contact-type or "cat-whisker" devices. An improved type, known as the junction type, has recently been developed but is largely in the experimental stage and under thorough investigation in the research laboratories of the principal manufacturers of the contact type.

The germanium diode, which derives its name from the two-element vacuum tube that it replaced for rectification purposes, is used in various types of electronic circuits, including radio, television, measuring-equipment, carrier-current (telegraphy and telephony), multiposition-switching, and voltage-multiplier circuits. Diodes have been made in small sizes by the millions for several years; about 6 million were made in 1951 and over 10 million in 1952. Large sizes for high-power applications are in production. Remington Rand has an electronic brain in operation containing 16,000 diodes.

The transistor (so named because it transfers an electrical signal across a resistor) was invented in 1948 by J. Bardeen and W. H. Brattain, of the Bell Telephone Laboratories. Invention of the transistor has been pointed to "as an example of how research directed at basic understanding of materials and their behavior, pure research if you will, sooner or later brings to the view of inventive minds engaged therein opportunities for producing valuable practical devices."

The contact-type transistor, which is essentially a triode form of the well-known crystal diode detector used in radio, can be used as a voice amplifier, a television picture amplifier, a pulse amplifier, and an oscillator. A survey made in the first half of 1952 indicated that production of contact-type transistors was then at the rate of 8,400 a month or about 100,000 a year, by five companies comprising the General Electric Co., Syracuse, N. Y.; Radio Corporation of America, Harrison, N. J.; Radio Receptor Co., New York, N. Y.; Raytheon Manufacturing Co., Newton, Mass.; and Western Electric Co., Allentown, Pa. The rate of production and the number of producers has multiplied many times since then.

OUTLOOK

Available domestic supplies of germanium appear to be ample to satisfy present requirements for the metal.

If the military services adopt the transistor and other germanium electronic devices as standard equipment, excess germanium production would be absorbed. Likewise, color television requirements could conceivably use up any excess germanium production. Stockpiling or mobilization coupled with increased civilian demand could create an acute germanium shortage.

TELLURIUM

SUMMARY

Tellurium is recovered metallurgically from anode slimes produced in the electrolytic refining of copper and lead. Blister copper is the principal industrial source of both selenium and tellurium and contains from 0.03 to 0.14 percent selenium and about one-fifth as much tellurium.

The principal uses of tellurium are in the manufacture of alloys, such as tellurium lead, tellurium copper, and tellurium bronzes, and in the rubber industry as a secondary vulcanizing agent. Minor uses are as an additive and a core wash to induce chill in the manufacture of iron castings, and as a coloring agent in the manufacture of art glass and ceramics.

Domestic consumption of tellurium has increased from about 1,000 pounds in 1928 to 22,600 pounds in 1935, to 89,000 pounds in 1940, and to about 100,000 pounds per year since 1950.

Production of tellurium in 1951 was almost twice apparent consumption, and producers' stocks of metal on hand and in slimes awaiting processing were about equal to a 9-year supply at the 1951 level of consumption.

The overall tellurium problem is the development of an increased demand for the metal, which would absorb the annual output which is produced in connection with the refining of blister copper.

A long-term program should have as its objectives, in turn, the development of new uses of tellurium through research; metallurgical investigations to increase recovery of the metal and to reduce losses in smelter and refinery operations; and investigations to discover new mineralogical sources of the metal and to recover additional supplies of the metal from such sources.

An emergency program might well consist of a short-term research program to develop new uses for tellurium.

An immediate program for the Bureau should include an investigation of the toxic effects of tellurium to develop protective and counteractive measures that would lead to its wider utilization in industry; a detailed economic study to disclose additional outlets for the metal abroad; and the initiation of research to develop new uses for tellurium and to promote the substitution of tellurium for selenium wherever possible.

USES

Much research effort has been devoted by Government agencies, educational institutions, industry, and others to the development of new uses for tellurium and the substitution of tellurium for selenium. From time to time new uses have been found, but they have largely provided either temporary outlets or outlets involving relatively small quantities of the metal. Endeavor to substitute tellurium for selenium has been, with relatively few exceptions, generally unsuccessful. Toxic characteristics of tellurium have operated against its wider use in industry; it imparts an odor resembling that of garlic to the breath of workers; it is a depilatory; and it is reported ot have other more harmful effects.

The principal uses of tellurium are (1) in the manufacture of alloys, such as tellurium lead, tellurium copper, and various tellurium bronzes, and (2) in the rubber industry as a secondary vulcanizing agent. Minor uses are as an additive and core wash to induce chill in the manufacture of iron castings and as a coloring agent in the manufacture of art glass and ceramics. Tellurium is reported to provide better porosity control than selenium in the manufacture of stainless steel castings, but industry prefers to use selenium owing to the toxic effects of tellurium. Large steel companies have also expressed a reluctance to use tellurium for the same reason.

Tellurium imparts hardness, toughness, and increased corrosion resistance to lead. Tellurium lead is valuable for lining tanks and for acid pipes and coils in plants handling sulfuric-acid and hot chromic-acid solutions.

A tellurium-copper alloy, 99.5 percent copper and 0.5 percent tellurium, with machinability approaching that of free-cutting brass and with electrical conductivity of 90 percent of that of pure copper—making it particularly well suited for the mass production of electrical and electronic connectors and other parts—has recently become available. Tellurium copper may be extensively hot worked, inasmuch as the addition of tellurium does not adversely affect the hot-working properties of copper. The alloy may also be severely cold worked, although it is somewhat less ductile at room temperatures than pure copper.

A tellurium bronze, 98.3 percent copper, 1.0 percent nickel, 0.2 percent phosphorus, and 0.5 percent tellurium, is also available for the production of forgings and screw-machine parts that require high strength, hardenability, ease of machining, and corrosion resistance.

Metallic tellurium is used in the rubber industry as a secondary vulcanizing agent to impart resistance to heat, steam, and aging, and to provide what the industry terms "a fast, tight cure."

Owing to the excess supply of tellurium available, producers are not disposed, for competitive reasons, to disclose outlets or end uses involved in their sales.

Indications are, however, that in 1951 about 75 percent of the metal sold found its way into alloys, and that about 25 percent was used in the rubber industry. This is a reversal of circumstances that prevailed in the early 1940's when 75 percent of the metal sold went to the rubber industry and 25 percent to alloy manufacturers.

Considerable experimental work involving the use of tellurium is reported in the electronics industry.

The representatives of the military services report adequate supplies of tellurium available for defense purposes and do not anticipate an increase in requirements at this time.

PRODUCTION AND CONSUMPTION

Bureau of Mines Report of Investigations 2385, published in August 1922, states "The present uses for tellurium are very limited, the demand being supplied by a few hundred pounds a year." Bureau of Mines Report of Investigation 6317, published in July 1930, states "tellurium has only slight industrial application. In 1928 the estimated output was 2,650 pounds, but sales apparently amounted to only 1,060 pounds." By 1935, however, sales of tellurium had reached 22,600 pounds, and in 1940 sales totaled 89,000 pounds. Since 1950 apparent United States consumption has been about 100,000 pounds per year.

Statistics show, for the 5-year period 1947–51, an average annual production of 112,802 pounds of tellurium and an average annual production of 514,988 pounds of selenium, a ratio of 1 to 4½. This ratio would appear to be well in agreement with the earlier statement that blister copper contains about one-fifth as much tellurium as selenium, assuming that the metallurgical efficiency in recovering the two metals from anode slimes is equal.

Senator MALONE. Would you name for the benefit of the record the text you will later submit?

Mr. KLINE. I would like to submit three platinum, gallium, and indium.

Senator MALONE. Do you have a short statement on each one of the materials that you could make for the benefit of the record at this time, and later submit the text?

Mr. KLINE. Yes, I could do that; actually they are very brief.

Senator MALONE. We will recess now and reconvene at 2 o'clock.

(Thereupon at 12:50 p. m., a recess was taken until 2 p. m., the same day.)

AFTERNOON SESSION

(The hearing was resumed at 2 p. m.)

Senator MALONE. The committee will be in order, and Mr. Kline will come forward to complete his testimony in reference to the rare and precious metals, industrial metals.

You may proceed with your statement and comments and continue where you left off before the recess for lunch.

STATEMENT OF M. H. KLINE—Resumed

PLATINUM GROUP

Mr. KLINE. I have a very few more I would like to mention hurriedly to complete the record. I have a statement prepared on the platinum-group metals.

The platinum-group metals include platinum, palladium, iridium, osmium, rhodium, and ruthenium. Platinum is the most important metal of the group, but the others are growing in importance. Based on their high melting points, resistance to chemical action, fine appearance, and workability, the platinum metals have specific uses in industry and in the arts and sciences. Platinum and iridium have

important military uses and are among the strategic and critical metals being stockpiled.

The domestic consumption of the platinum metals far exceeds domestic production, and importation of these metals from abroad is essential. No duties are imposed by the United States on imports of platinum metals in ores or in unmanufactured form, but platinum manufactures are subject to duties ranging from 25 to 55 percent ad valorem.

The world annual output of platinum-group metals is about 600,000 to 700,000 ounces. Canada, Alaska, the United States, and Colombia produce about 176,000 ounces.

Because of the military significance of platinum, sales for nonessential uses were prohibited during World War II. Similar restrictions were in effect from early 1951 to early 1953.

There are no substitutes.

Recommendations: (*a*) The maintenance of an adequate stockpile. Fortunately, I understand the stockpile is in pretty good shape.

(*b*) Restricted uses of platinum for nonessential uses during time of emergency.

(*c*) Conversion of secondary recovery metal to essential usage.

Senator MALONE. Right in line with your general testimony, I note in the chart prepared by the Bureau of Mines that we could become self-sufficient in Western Hemisphere in platinum metals, if technological changes permit the use of known submarginal resources.

Mr. KLINE. I think that is true, Senator, especially if we consider South America and Canada.

Senator MALONE. Yes; of course, you would. It would be the Western Hemisphere, also South America.

Mr. KLINE. A great deal of our platinum production depends on nickel production, which usually goes up in time of war.

Senator MALONE. It is a byproduct of the nickel production?

Mr. KLINE. That is right.

Senator MALONE. Then I think that is sufficient.

You made some reference to the fact there is no tariff on the raw material. Is that not customary? Has there ever been any duty, to your knowledge, on any material that is not produced in quantity in the United States?

Mr. KLINE. Not to my knowledge.

Senator MALONE. There has not been, to my knowledge. Later, we will hear from Dr. Coulter, who is an expert in that field, and perhaps he will cover it in his testimony. But sometimes there is a misapprehension in the public mind that the United States charges duties or import fees or tariffs on materials that are not produced in the United States. I think 75 years ago we did for a while collect duties for revenue purposes, but very soon abandoned the policy. Many other nations still do follow the policy of collecting duties and import taxes for revenue.

So your statement that we could, under a comprehensive program, become self-sufficient is very satisfying to the committee.

GERMANIUM

Mr. KLINE. The next commodity is germanium. Germanium production depends almost entirely on the welfare of the tristate zinc industry since it is recovered in the smelting of ores. We presently have under way a research program for extracting germanium from coal which promises fair success. The production figures are very favorable. They are in excess of consumption.

As you probably know, germanium is used to make these miniature tubes which I showed you this morning, which is of increasing interest in jet-propelled planes and rockets because of their light weight and smallness in size.

Senator MALONE. I hope you will be able to find the time to prepare for us a card or a compilation of these materials that can be subject to inspection in the committee, if it is permissible.

Mr. KLINE. We certainly will be glad to do so.

Senator MALONE. Thank you.

Mr. KLINE. The germanium industry's future is quite uncertain, largely because we do not know exactly where the semiconductors are going to fit. I mean certain areas. Selenium can be substituted for germanium. Silicon can be substituted for one of the others, and several other combinations of compounds may have an overlapping function.

Senator MALONE. There is no scarcity of the material in the United States?

Mr. KLINE. No; not in any way.

Senator MALONE. Of course, the welfare of the zinc industry in the tristate area might have some influence on its production?

Mr. KLINE. That is correct.

Senator MALONE. Thank you.

TELLURIUM

Mr. KLINE. Another metal we would like to mention is tellurium, which comes along more or less as a byproduct from selenium. Again, production with regard to consumption is very favorable. There is no shortage. The only problem of the industry is to find new sources for using this metal in industry.

Senator MALONE. Will you describe in general what it is used for?

Mr. KLINE. It has a very limited use to date. That is one of the reasons why we have a problem with it. The Bureau of Mines has done and will continue to perform research to more or less develop or outline a field in which this commodity can be used. There is some hope it may be used as a substitute for selenium in some particular applications.

Senator MALONE. You will continue your investigation and laboratory work in the field of substitutes?

Mr. KLINE. Yes. We hope to make these commodities, of which we have an excess, substitutes for those in which we have shortages.

At present, it is used almost entirely in rubber vulcanization and making some alloys with iron.

Senator MALONE. There is no scarcity in the United States?
Mr. KLINE. None whatsoever.

GALLIUM

Another extremely interesting metal is gallium, which has the longest range in the liquid state of any metal we know. We are all acquainted with mercury, that within certain temperature areas is a liquid. Gallium has that same property, only the range extends over 3,000° F. It is of particular interest as a heat transfer medium when we think of these new atomic-energy powerplants.

In 1952, no gallium was produced in the United States. In previous years as much as several hundred pounds have been produced.

The limited consumption has been supplied from stocks of smelting companies. Tons of gallium could be produced annually in the United States from zinc waste residue, waste liquors, from aluminum refining, and from waste materials in the refining of tin.

Its usage is limited entirely to the field where a long liquid range is of advantage, such as high-temperature thermometers, electron tubes, rectifiers, plating for optical mirrors, excitant in phosphors for fluorescent lighting and luminous paints, and medicine. Its greatest anticipated use will be as a heat exchange medium in the atomic-energy powerplants.

Mr. HOLDERER. At present there is little use for the hundreds of tons that could be produced?

Mr. KLINE. That is right. Usage limits production.

INDIUM

Indium is also an attractive metal in the field of rare metals. Several hundred thousand ounces annually are produced. Production could be increased greatly from Butte and tristate zinc refining dusts and residues now being wasted. Consumption is limited because of the high cost of the metal and large amounts are available from the refining of zinc-lead ores in Peru and Canada.

The chief use is in alloys in engine bearings. It gives extreme life to a bearing because it has a self-lubricating property. It is also used in the plating industry. It is a very beautiful, nontarnishing metal, which resembles silver to some extent.

It alloys with tin to make glass-glass, or glass-metal seals.

It is used as an internal lubricant similar to graphite. It also shares with germanium a property which is necessary to produce transitors. Tin could be substituted for it in many alloy uses.

In order to encourage industry toward further use of this metal, it is recommended that some conservation measure be taken with regard to the saving of indium-rich waste materials now being discarded, develop methods of upgrading indium residues so they can be stockpiled, and develop cheaper extraction methods.

CESIUM AND RUBIDIUM

Then we have cesium and rubidium which are very similar in nature. They are principally produced from the complex lithia mica lepidolite and other amounts from pollucite, a hydrous silicate of alumium and silica. Production of these alkali metals is mostly from large reserve

stocks in the hands of producers. Most ores are supplied from South African mines where lepidolite and pollucite are produced cheaper than they can be from United States sources. No attempts have been made to develop cesium and rubidium ores in the United States, though minor amounts have been produced as byproducts from the mining of pegmatites for beryl and mica in Maine, South Dakota, Colorado, and other States.

Actual production and consumption of these two metals can be measured in hundreds of pounds.

A most interesting use, of course, is in the manufacture of photoelectric cells and they were also used extensively in the war to make instruments known as the sniperscope or snooperscope. I am not sure which is the accepted name. Anyway, it was a piece of equipment that was attached to a gun so that the enemy could be seen in the dark. I understand it was used quite extensively in Asiatic warfare, especially in the jungle country where at night you could not detect the enemy by vision but you could by infra red light, and these snooperscopes made it possible to detect the enemy.

Of course, this is true of most of these rare metals that we have mentioned here, while they are not produced in great quantity, nor account for a great amount of the country's economy, they do have strategic purposes that are almost essential in time of war.

We have no known substitutes.

It is recommended that ore reserves be developed within the United States so that we may become self-sufficient. Research is recommended for ore-dressing studies to separate the minerals and an attempt should be made to develop cheaper metallurgical methods for extracting these metals.

Mr. HOLDERER. There is room for further research on all of this?

Mr. KLINE. That is correct.

Mr. HOLDERER. Does that conclude your statement?

Mr. KLINE. That concludes my statement.

Senator MALONE. Thank you, Mr. Kline. The committee appreciates the statement you have given us today.

Mr. KLINE. Thank you, Mr. Chairman.

Senator MALONE. I think we will recess until 9:30 in the morning. Tomorrow we will make an earnest effort to complete the testimony of the engineers of the Bureau of Mines. That will include Mr. Pehrson's testimony.

Did I understand that you cannot be here tomorrow, Mr. Pehrson?

Mr. PEHRSON. I am sorry I cannot, sir.

Senator MALONE. If you will come forward, we will spend some time here with your testimony, and then perhaps at some later date when the committee returns to Washington, we can get a summation of it.

STATEMENT OF ELMER W. PEHRSON, REGIONAL DIRECTOR, FOREIGN MINERALS REGION, BUREAU OF MINES

Senator MALONE. Mr. Pehrson, I have been familiar with your work for many years, and I think you are in one of the most important fields of work and in one of the most important organizations in the Nation. I know you have personal knowledge of the possibilities of production in the United States, the Western Hemisphere,

and in many nations of the world. I regret that our time will be limited, but if you could identify yourself for the purposes of the record and make any general statement you care to make, and if we do not complete your testimony at this time we will make a point to have another discussion with you around the middle of next month.

Mr. PEHRSON. I am very sorry that I shall not be able to be here tomorrow.

Senator MALONE. That is all right.

Mr. PEHRSON. My name is Elmer W. Pehrson. I am a mining engineer by profession. After several years of experience in the mining industry of the West, I joined the Federal Government in 1926; first as valuation engineer in the income-tax unit of the Bureau of Internal Revenue, and since 1928 with the Bureau of Mines in various positions. At the present time I am regional director of the foreign-minerals region.

In 1939 and 1940 I served as secretary of the Minerals Advisory Committee to the Army-Navy Munitions Board. That was a professional group made up of men outside of Government.

From 1940 to 1949 I represented the Secretary of the Interior on the Army-Navy Munitions Board Stockpiling Committee.

As you know, Senator, I have been very much interested in the problems of United States mineral supply and particularly with the security angles. I had intended to state briefly what the present position of the Nation was as I saw it, why the situation is as it is, and what we should do about it. Then I had intended to discuss some of the availability problems that arise in connection with minerals indicated as potentially available on charts previously presented by the Bureau of Mines, particularly with respect to foreign sources.

I am very anxious to get this general part of my statement into the record, and I shall, of course, be happy to appear at any other time that you state.

Senator MALONE. You may proceed.

Mr. PEHRSON. I shall preface my remarks by reading a very short introductory paragraph:

> The chaotic political and economic conditions existing in the world today, with their sinister implication of widespread warfare, present an effective setting for serious consideration of our strategic mineral problem. We of the mining industry need not be reminded that mineral raw materials are the foundation of industry and in consequence the very keystone of national defense.
>
> We are well aware also that the game of international politics usually is played with deposits of coal, iron, and petroleum as the ultimate prize and that the offensive tactics of certain belligerent nations are motivated in no small degree by their desire to possess more of the earth's mineral wealth.
>
> Unfortunately, however, the importance of minerals in our modern industrial civilization is not fully appreciated by the American public, and for this reason and the fact that we are essentially a peace-loving people we now find ourselves facing an uncertain future with much of our strategic mineral problem still unsolved, despite the bitter experiences of two decades.

That statement, Mr. Chairman, was not prepared recently for this meeting. It is the introductory paragraph to a speech by John Wellington Finch, Director of the Bureau of Mines, which was delivered to the American Zinc Institute in April 1938. It seems to me that it still is a good description of the situation we find ourselves in in this country.

I hope to analyze the reasons why we are still in that situation, but before doing so I would like to read an additional excerpt from Dr. Finch's paper which is as follows:

> In the foregoing remarks I have endeavored to outline a sound method of attacking our deficiency mineral problem. The method involves two steps: One, the immediate purchase of adequate stockpiles of strategic minerals of standard quality as the most effective means of meeting the pressing problems of national defense; and, two, the annual appropriation by the Government of $500,000 to be used by the Bureau of Mines and the Geological Survey for the purpose of a comprehensive study of ways and means of adapting our domestic reserves of strategic minerals to a permanent solution of our deficiency mineral problem.

That two-point proposal, Mr. Chairman, is the identical program that was enacted into the first stockpiling act, Public Law 117, 1939; and I call attention to it at this time because I want the record to show that the Bureau of Mines is not a Johnny-come-lately in its concern over the Nation's mineral position.

Incidentally—and I think I may say this in good grace where the Director of the Bureau of Mines might not feel that he could—we proceed with the hope that at such time as the Malone mineral policy for the United States, which will be formulated by this subcommittee, is enacted into legislation the Congress will see fit to place the responsibility for carrying out that policy in the Department of the Interior, where the program will have the sympathetic support of the Bureau of Mines and Geological Survey, two agencies that command the respect of industry and which have the good sense to work with industry. I think the testimony of our commodity people has shown that we have an understanding of the mineral problems and ideas on how to solve them.

So if I may be pardoned for putting in that little plug, we will proceed with the meat of the discussion.

Senator MALONE. I will say at this point that in hearing the testimony of you men who have long been connected with the Bureau—one of the soundest bureaus ever established in the Federal Government, in my opinion, when you were allowed to exercise your judgment—we not only want your testimony as to the facts, but your ideas. I am sure they will be helpful to this committee because the besetting sin of the Government is the general acceptance of ideas from someone who does not have background experience in the subject which they are trying to discuss.

I have been extremely interested in the testimony of the three witnesses we have heard to date from the Bureau. As far as I know, this is their first committee appearance. Someone is generally talking for them. They have brains and experience, or they would not be in their positions.

So I believe that the Senate of the United States should utilize the background, experience, and training that the personnel of your Bureau have. I intend as chairman to see that the information reaches the committee.

Mr. PEHRSON. Thank you. I am sure you will find us all more than willing to cooperate.

Now let us examine this situation that we find ourselves in. We are trying to find out the fundamental reasons why the problems are still unsolved.

One of the reasons we are in the position we are in is because we have not succeeded in selling to the Congress, to top Government officials, and the public the fundamental importance of the mineral industries.

Dr. Finch, I thought, expressed it very well in the statement that I quoted earlier. It seems to me if we could get over this idea that we are dealing here not with just an ordinary commodity but with the very fundamentals on which our national well-being and our security rest, we could get a better audience, a better hearing, and have a more effective mineral policy.

If we could broadcast and get thoroughly understood by the public at large and by our Government officials that the reason our country, which represents only 6 percent of the world's population, can come up with 50 percent of the world's industrial output is largely because we have these outstanding mineral resources and have done something with them, then I think we could get more attention paid to the problems of the mineral industries and the problems of mineral supply.

Your hearings are certainly developing a fund of information which should go a long ways in achieving this objective, and I hope you are successful in broadcasting the data to all corners of the land. I hope you can get your committee and other committees of the Senate to read the summaries that will come out of this hearing.

Other reasons why we still find ourselves in a position of lacking minerals, and I think we would be less than candid if we did not recognize them, are depletion and the lack of resources of some commodities. Opinions differ, of course, on the extent to which depletion has progressed in some of the industries, but the record shows clearly that we are having difficulty in expanding production of some commodities to keep up with expanding needs, and that we are unable to produce significant quantities of others.

Another reason for our lack of a sound national mineral policy is because the mineral industry as a whole is not organized to lobby for the best interests of the Nation and the mineral industries of this country. I use the term "lobby" in its constructive sense, Mr. Chairman.

Another reason why mineral production does not meet national requirements is the fact that the mineral industry must operate under a wage pattern that is not determined by the economics of the mineral industry. It is determined by the economics of the manufacturing industry, and the manufacturing industry is able to pass on the added costs of higher wages to the public.

The miner finds himself in competition with foreign producers and not in a position always to pass on the added costs, and therefore he has to operate under a wage pattern that bears little relation to his basic economic problem.

There is another reason why we are lacking a sound national mineral policy. We do not have a focal point of responsibility for the mineral economy of this Nation in the executive branch of the Government. The net effect of that is that we have too many cooks stirring the broth. Mr. Williston has given a classic example of the confusion that exists in Washington when you are trying to do something in the mineral field.

The State Department is virtually supreme in dealing with the international aspects of our mineral problem. The Treasury Department is supreme in matters relating to mineral taxation. The Military Establishment is supreme—until recently at least—in handling matters of security, and that includes the establishment of the broad principles governing the Government's stockpiling program.

Finally, we have the Interior Department which conducts geological work, research, and fact finding, but has virtually no authority in the policy field and frequently is ignored when policy is formed in other agencies. If its advice is sought, it is frequently not followed.

So it seems to me that there is an opportunity for your committee to make an exceedingly constructive suggestion to the Congress, that we need to bring these responsibilities together and get them under a head who knows something about the subject. When that is done, give him enough authority to act without the benefit of restraint by starry-eyed economists.

Now let us get down to some of the general aspects of our mineral problems. What can we do about them? The first thing we have to do is to pinpoint our objectives. To me that means that we have got to make up our mind whether we are living in a world of peace or whether we are living in a world at war. Do we have a struggle between communism and the free world? If so, it seems to me that we are in a world at war and our policy should be guided accordingly.

I am one who believes that our mineral program should assume that global war is a possibility at any time and that we should not coast along in the belief that a benign atmosphere of brotherly love exists or that peace is going to rule the world.

If we start out with that assumption, it is easy to pass to the next conclusion which is that we must have our raw materials' supplies in such shape that we can guarantee, without question, that the arsenal of democracy will function when war comes; and the industrial strength of this country is the arsenal of democracy. Unless we have the minerals here to use, it will not function.

We need to consider some of the broad policy changes that are needed in order to accomplish a sound mineral program. For one thing, our stockpiling program is pitifully inadequate. The principal reason for that is that the program to date has followed the narrow military concept of security rather than the broader overall security concept.

The other day I listened to Congressman Martin, who expressed considerable disappointment in the shortcomings of our stockpiling program and seemed to take the military to task for these shortcomings.

Senator MALONE. By the way, you might say whether or not you in general agree with Congressman Martin's position.

Mr. PEHRSON. On the stockpiling aspect?

Senator MALONE. Yes.

Mr. PEHRSON. As far as his feeling of disappointment that we are not further ahead in the program, I do agree with him; but the difficulty is that when you narrow your stockpiling program to strictly military concepts, you raise immediately the problem of total security versus calculated risk.

The military man looks at the job of fighting a war from the viewpoint of a balanced program, and he sees no need for having a 100-percent assurance in raw materials if he has only 80-percent assurance

in munitions. Conseqently, the stockpiling program is tailored more or less to coincide with the overall status of our military preparedness.

Also, the military have, right from the start, taken the point of view that stockpiling for a national security objective in the military sense should be just that and should have no elements whatever of subsidy to domestic industry in it. Consequently, they have been very reluctant to get involved in any of the broader aspects of stockpiling, which many of us think could serve a most useful purpose in stimulating domestic industry.

Senator MALONE. From your statement, I judge that you think a going concern mining industry would be one of the greatest safeguards to national security.

Mr. PEHRSON. Under my concept of not settling for anything less than 100-percent security in the mineral field, we should settle for nothing short of domestic production plus physical stockpiles within the border of the United States equal to any possible emergency needs.

Senator MALONE. A going concern mining industry.

Mr. PEHRSON. Exactly. I think that stockpiling could be well integrated into any program of expanding mineral production or to offering incentives to new industries. It seems to me the evidence that has been presented here indicates that there are opportunities for substantial improvement in some of these unusual strategic minerals if we only provide enough incentive to carry them through the organization stage.

Senator MALONE. Then, as I understand your testimony, you would oppose any manipulation of the stockpile accumulated for national security which would affect the market in this country.

Mr. PEHRSON. I think the existing law safeguards that quite adequately, Senator.

Senator MALONE. Perhaps if it were carried out as Congress intended, but the testimony here shows that by assuming the existence of an emergency the Executive could always remove materials from the stockpile and put them on the market. Testimony was presented here that it had been done several times, and the Government even paid the tariff when they transferred it to private industry at one time; simply because the Government pays no tariff on materials for its stockpile, but it should have been paid when the materials were transferred to private industry.

Nevertheless, they did transfer it without that payment. Furthermore, emergency has been interpreted to include political emergencies in order to release material from the stockpile, according to Congressman Martin's testimony.

So again I would ask the question of you; and you apparently believe that it is properly safeguarded, and it probably is if you or the chairman of this committee or Congressman Martin were administering the law. But the law has been abused in its administration; that is, provided the law intended that the stockpile would not be depleted for the purpose of manipulating the market here.

Then I would ask you if you do believe, as I take it you do, from your testimony, that the law should be tightened so that such manipulation would be impossible.

Mr. PEHRSON. If the law isn't tight enough now, I certainly think it should be made perfectly tight. On the other hand, we must realize that if war comes to us in the near future, it is going to be fast and

furious. I think the Executive should be given sufficient latitude so that he can act promptly.

Senator MALONE. War would be a real emergency. We are stockpiling for a purpose, and that purpose should be the emergency.

Mr. PEHRSON. That I certainly subscribe to, and I can assure you from all of the negotiations that went on in the executive branch of the Government in advance of the passage of the second stockpiling act that that was certainly contemplated.

Senator MALONE. That was the intention of Congress?

Mr. PEHRSON. That was the intention of Congress, and it was the intention of the executive agencies that the stockpile, once acquired, would be sacrosanct. There were several reasons for that. For one thing, it was a military security measure, and you want to be sure you have the materials when the shooting starts.

The second reason was that industry does not want the accumulated stockpile overhanging the market all the time, constituting a threat.

Senator MALONE. In other words, it was testified to here—and documents were submitted which support this statement—that Government money through ECA and Mutual Security had been given in large quantities to a certain nation to purchase three specific metals: copper, zinc, and lead; and the stockpiles so accumulated in this particular country were used to break the lead and zinc market in this country. You do not subscribe to any action like that?

Mr. PEHRSON. If that was the purpose, I do not. I am not familiar with the details of stockpile activity since 1949.

Senator MALONE. That was the testimony, and it seemed to be very clear and well documented.

Mr. PEHRSON. I noted Congressman Martin's disappointment in the way the military had handled the stockpile. I think it would be just as well for the record to show that the stockpiling legislation submitted to the Congress by the executive branch of the Government provided for civilian control of the stockpiling authority. The Congress itself wrote the military authority into it.

We recognized at that time—that is, the civilian agencies in the executive branch—when postwar stockpiling legislation was under consideration, that there were broader objectives that could be accomplished under a stockpiling program; but once the thing got in the hands of the military, we were limited in the actions that could be taken for other than strictly military objectives.

Another aspect of the stockpiling program that has presented a difficulty because of its strictly military nature is the ground rules on which stockpiling objectives are calculated.

Some of us felt, and I think all of the mineral men who were associated with the Munitions Board Committee felt, that we should plan our stockpile so that we would not have to depend at all on hazardous sources of supply in an emergency. But that proposal was overruled. As late as 1949 the Director of the Bureau of Mines proposed to the Strategic Materials Committee of the Munitions Board that stockpile objectives be computed on the basis that we would count on imports only from contiguous land territory. That amounts to Mexico and Canada. There wasn't even a second for the motion in the committee.

I don't know what the present ground rules are. They are highly restricted, of course. However, I believe that the present stockpile ob-

jectives assume that we are going to be able to get materials from distant sources in an emergency. I am not sure that they have even yet eliminated all the Eastern Hemisphere sources.

In the light of experience and in the light of the testimony already given to this committee, any large dependence on seaborne strategic materials during war must be regarded as exceedingly hazardous. There is no necessity, if we have enough time, for running that risk. All we need is to have the good sense to spend a little money now and make sure that we have the materials within the confines of our own country.

Senator MALONE. What you believe, then, is that we should bend every effort toward increasing our domestic production to the point where we will have a going concern domestic mining industry; a program by which the availability of the strategic and critical materials and fuels from the Western Hemisphere is assured; and to supplement the production from the Western Hemisphere with stockpiles so that when a real emergency comes we will have the necessary minerals, materials, and fuels without having to import these materials across an ocean.

Mr. PEHRSON. Yes. I assume, Senator, when you state that we should stimulate domestic production, that you have in mind that the rule of reason will prevail and that we would not go to exorbitant high-cost operations.

Senator MALONE. You have heard the testimony here about a going-concern mining industry, and I believe most of the witnesses have agreed, like Dr. Coulter this afternoon, that you must make up the difference in the cost of domestic and foreign production. The difference between the wage standard of living here and abroad may be the principal factor but it is not the only factor. When a domestic producer can compete and survive in competition with other United States producers, then he must not be run out of business by lower cost production from some foreign country.

Mr. PEHRSON. In principle, I think that is a desirable type of policy. However, I want to call attention to the classic example of possible abuses under a protective system, and that is the growing of bananas in Maine. As long as we are not thinking in terms of that——

Senator MALONE. We have gone into bananas and all that sort of thing, and as far as I know there never has been an attempt to do anything of the kind. I debated that matter with Senator Douglas on television and he has been trying to get out of that debate ever since.

Sixty percent of our imports are not subject to any tariff. Nobody has ever proposed a tariff on anything like that, except as Dr. Coulter so ably explained this afternoon, to encourage laboratory experiments and research in order to establish a necessary industry.

You heard his testimony. I absolutely agree with it; do you?

Mr. PEHRSON. I think his point was well stated, and as long as we recognize that when we have a low-grade resource such as we do in the case of manganese and it faces exceedingly formidable competition in the high-grade resources which exist in other parts of the world, we want to give every encouragement to research to try to narrow the economic gap between production from that kind of resource and importation.

Senator MALONE. I think you are absolutely right. Every agreement to purchase we make should be made on the basis of our own costs. The consumer in this country gets no advantage.

For 2 days we heard testimony from the men who are in charge of purchases for the stockpile. We heard men who are recommending or at least who have something to do with purchases through ECA and Mutual Security. I believe you were here.

At any time did you hear of any contract where the consumer in the United States got the advantage of the low-cost labor?

Mr. PEHRSON. That, of course, is something that is very difficult for me to accept. I never could see why we should give a more favorable contract to a foreign producer than we would to our own domestic producer.

Senator MALONE. To me it is silly, and I am glad to hear you say that—silly and dangerous.

Mr. PEHRSON. If we enlarged this stockpiling program and gave the direction of it to experts in the mineral field, it would seem to me that that would be an excellent opportunity to offer to venturesome producers in this country a long-term contract at a fair price and give them at least that much incentive to go ahead with production.

I understand that possibly something of that kind might be done with the Maine manganese resources at the present time.

Senator MALONE. I was very much interested in Mr. Kline's testimony when he got into the field where we have no production of the raw materials but where we know, or have reason to believe, we have them. Under special contracts we furnish protection to the men who are willing to go out and do this job and thereby we get into production.

I was both surprised and gratified at Mr. Kline's testimony that we could do this job right here in the United States of America in several fields where for 21 years we have been told that we had no material at all and had to depend on foreign sources.

Testimony has shown here that we can arrive at the condition they are predicting as the policies they install finally bring about the very thing they say they fear.

Mr. PEHRSON. Under the heading of incentives for domestic production and exploration, I might say that I have been a little disappointed so far that there hasn't been any particular emphasis on the need for considerable stimulation of exploration in this country. Such stimulation should be a part of our national mineral policy.

I am a great believer that Government should subsidize submarginal fundamental research. Most of these wonderful accomplishments that the Bureau has been able to make in electrolytic manganese, titanium, zirconium, and in the exploration and discovery of monazite, started many years ago as ideas in some fellow's head. To bring those ideas to fruition takes a long time.

We have to do a lot more fundamental research, and I have no doubt that the commodity people of the Bureau have many ideas along this line. Some of them have already suggested research that is just crying to be done.

In the field of taxation, to give you an illustration how the present lack of a focal point of responsibility in the executive branch of the Government hinders progress, in 1948 the Director of the Bureau of Mines got the idea that domestic mining needed some incentive and that relief in the tax field would be a very effective means of achieving that incentive.

So the Bureau hired one of the outstanding mineral economists of the country to make a study of taxation. The powers that be decided

that before we should go further, the project should be cleared with the Treasury. When we got over to the Treasury we were confronted with the stonewall that they would not consider any program that would reduce the total tax take from the mining industries.

They stated—and we can well appreciate their problem—that they were so hard-put to balance the budget that they simply could not consider anything which was going to reduce tax income. They did say that if we had any ideas of shifting the tax burden within the industries without reducing the total take, they would be glad to consider them.

Senator MALONE. Along that line maybe your organization and certainly the producers could give them some valuable information to the effect that, no matter how high the tax rate or no matter how many taxes are being secured, if the industry goes out of business it is not going to increase the revenue very much.

Mr. PEHRSON. The point is we need somebody in the executive branch of the Government who has the knowledge and the authority to drive through, insofar as the executive branch is concerned, these points of policy that are so important to the welfare of our mineral economy.

The question of tariffs and subsidies has already been explored in considerable detail. I think the treatment that has been accorded the mineral industry under the Reciprocal Trade Agreements Act is against the best interests of the country, and it illustrates again the lack of understanding of the basic importance of minerals. Under that policy and under almost any broad program or policy of the National Government, minerals are accorded the same treatment as shoelaces, collar buttons, bicycles, and razor blades when we should realize that we are dealing with commodities that are just as important as tanks, guns, and ammunition. I think if we could get that idea across we would find the mineral industry getting more favorable consideration in matters of fundamental policy.

We also need greater recognition of the fundamental importance of minerals in foreign policy, not only with respect to our own domestic mineral economy, but also with respect to other factors.

As an illustration of our naivete in international affairs, I would like to call attention to the fact that we let China slip under Russian control, and by so doing the free world lost access to the world's greatest resources of antimony and tungsten, and Russia gained access to those resources as well as to substantial resources of tin, molybdenum, and mercury—all commodities that she was short of before the conquest of China.

Senator MALONE. Many people of my acquaintance would think you are very charitable in your statement when you say we simply lost control of China. Some think that she had a little help in shifting her allegiance even from within our own country.

Mr. PEHRSON. We also had our army of occupation in South Korea for several years. The largest tungsten mine in the world was producing there. It has been only in the last few years that we have had the good sense to make a deal with the Koreans for the tungsten.

They also have profited by it. They get our dollars. We get their tungsten. We need tungsten. It has been testified before this committee that our tungsten stockpile is probably considerably behind schedule.

So I say we need a little mineral sophistication in the implementation of foreign policy. I also think that we need some basic changes in our concepts of foreign policy.

In a book written shortly before the war Walter Lippmann called attention to the fact that our foreign policy in years past had been something less than successful and adequate, and he thought the reason was that we were too idealistic and were lacking in self-interest.

Senator Lodge expressed the same opinion in a speech before the Senate in June 1943, at which time he also called attention to problems of mineral deficiency in the United States.

I think there is ample justification for making the suggestion that we ought to get a little quid pro quo into our foreign policy. That to me means that as a nation we should, after careful study, determine what our objectives in the international field should be. Diplomacy then should be a means of achieving those objectives instead of having the mineral industry used as a pawn in international negotiations, as has been the case some times in the past.

In the implementation of our foreign policy we need a rededication to the principles of private enterprise. We parade ourselves before the world as a shining example of progress under a free enterprise system, and yet we permit ourselves to become involved in all kinds of socialistic agencies conjured up in cooperation with socialistic governments, chiefly in Europe; and I cite as a classic example of that the Habana Charter for the International Trade Organization. If we really believe that free enterprise is the secret of our success, we ought to show it in our dealings with other nations. Incidentally we could use this suggestion to good advantage at home. In recent years many ill-advised Government actions have been based on the concept that profit was sinful. Too often in the past the fact that profit is the heart of a private enterprise system has been ignored by left-wing idealists in Government who were in a position to veto programs devised by experienced Government and industry experts.

Senator MALONE. Do you believe that the actions taken at Geneva based on the 1934 Trade Agreements Act, and the proposal for an International Trade Organization and more recently the International Materials Conference in any way promote the situation you describe?

Mr. PEHRSON. I take consolation in the fact that the Congress has never dignified the Habana Charter with its approval. I believe I am correct in that statement.

Senator MALONE. You are so far correct, and I hope that we can maintain our position.

Mr. PEHRSON. As far as the international allocation of raw materials is concerned, I think we have to recognize that when we are on the brink of war we certainly have to have some kind of cooperation in the distribution of scarce materials in order to avoid complete chaos.

I am not sufficiently familiar—I was not involved in it at anytime—with recent activities to have any worthwhile opinion on that particular experience.

When considering these matters of broad principles in our national policy and their impact on the mineral industries, we must not lose sight of the fact that the water is almost over the dam.

The Paley report has been commented on adversely by many of the witnesses before this committee. I believe that there is much

good in the Paley report. The fundamental data brought together in the report are extremely useful. However, the forecasts of requirements involve such a degree of risk and uncertainty that they should not be used as the basis for formulating national policy and I have other objections.

The recommendation of the Paley report which I object to most strenuously is the one regarding self-sufficiency. In effect it states that as a nation we should give up the idea that self-sufficiency is good and seek our raw materials from the cheapest sources.

If we were living in a benign world of brotherly love that type of policy might have some validity, but I think we are right down to the brass knuckles proposition of war in the not too distant future, and I certainly don't feel that at a time like this costs are the controlling consideration.

Security is the controlling factor in the present situation.

Senator MALONE. I might ask you at this point if you agree with many critics of the present policy when they state that if each nation should be allowed to produce that which it can produce cheaper, it means we will import the products of sweatshop or low-cost labor principally, and when they talk about expensive products they are neglecting to state that what they are really objecting to is paying American wages.

Mr. PEHRSON. Undoubtedly the disparity in wages here and abroad is an important factor, but in the mineral field I don't think it is the only factor.

Senator MALONE. It is not the only one, but wouldn't you say it is one of the main ones after the machinery is purchased?

Mr. PEHRSON. Certainly it is one of the main ones, but in many areas of the world the low-cost labor is more than compensated by the high grade of raw materials.

So I would make this suggestion: That if we are moving into a tariff program—and I personally favor a protective tariff for industries that can supply a substantial proportion of our needs of raw materials—if we are moving into tariff considerations, we have to compensate for more than wages. We have to compensate for differences in grades of raw materials. I think that is a very important point.

Senator MALONE. Wouldn't you say that if we were to allow the 1934 Trade Agreements Act to expire in June 1954 and Congress instructed the Tariff Commission to arrange a flexible tariff or import fee or duty on the basis of fair and reasonable competition, it would cover considerable territory?

Mr. PEHRSON. I would wish to speak to that question only insofar as it applies to minerals.

Senator MALONE. I am talking about minerals.

Would you agree that to do that job on the basis of fair trade and to fix the flexible import fee or duty or whatever it might be called on the basis of fair and reasonable competition, would be in general a fair principle?

Mr. PEHRSON. That is essentially the basis on which tariffs were set under the old scheme.

Senator MALONE. That takes in all the factors.

Mr. PEHRSON. The Tariff Commission would make studies of costs, and Congress would act accordingly.

Senator MALONE. Under the 1930 Trade Agreements Act it was not even necessary for Congress to approve the rate. Congress could disapprove any rate it wanted to, but the Tariff Commission had a rather free hand in its recommendations.

Mr. PEHRSON. In connection with the escape clause which the lead and zinc industry has now been forced to seek relief under, I think we should not delude ourselves into thinking that if we reestablish the 1931 rates we are going to solve the problem of lead and zinc.

Senator MALONE. Not the rates, but the principle.

Mr. PEHRSON. If we could establish the same percentage ad valorem as applied at the time the 1930 Tariff Act was passed, I think we might have a fair basis.

Senator MALONE. I would say to you that I would have no more idea, if I had the recommendation to make, to go back to the 1930 or 1931 rates on zinc than the 1930 or 1931 rates in the purchase of a suit of clothes. I think it would be impossible.

But you can go back to the principle of fair and reasonable competition, and probably arrive at a new rate that would be entirely satisfactory on the basis of fair and reasonable competition. Wouldn't you think so?

Mr. PEHRSON. I would think that that would be a fair approach to the problem.

Senator MALONE. No one of my acquaintance—and for 21 long years I have heard the complaints of the people who want free trade, either because they want to establish an industry behind a low-wage curtain and send the goods back into this country, or they are economic "One Worlders," or the Atlantic Pact nations, or they have some do-good idea that all you have to do is divide your wealth with the nations of the world and you will have perpetual peace—regardless, I have never heard any one of my acquaintances that understood the tariff structure say they want a high or a low tariff. They want a tariff based on fair and reasonable competition or fair trade.

Mr. PEHRSON. I would like to point out in connection with the Paley report that, as I read the news and as I observe the actions of the various commissions that are investigating our foreign economic policy, the Paley Commission recommendations are already accepted as national policy or are presumed to represent national policy.

Senator MALONE. There is no question about its being national policy up until 1953, and there is no question but that our President asked for a year's extension of the policy in order that a commission could examine the policy and make recommendations.

Mr. PEHRSON. I think it is exceedingly important that some articulate group that can speak with authority get some different viewpoints into the record because, if not, I am afraid the concepts of a sound mineral policy that many people believe in are going to be lost by default. So my admonition here is one of speed.

That is about all I have to say on the general subject of policy and our mineral position.

We could spend considerable time reviewing the self-sufficiency chart presented by Bureau representatives earlier in the hearing. It may be just as well to postpone that until some future time.

Senator MALONE. I was going to ask if you agree with the implications of the October 15, 1953, chart submitted and prepared by the Bureau of Mines?

Mr. PEHRSON. I certainly could not challenge the validity of the facts and judgment shown here, particularly since they have been prepared by such a distinguished group of experts. However, probably none of them would go on record as saying that these are easily attainable potentials, and therein lies an area of caution that I would like to inject into this discussion, Senator.

There is a danger that we might have a repetition of what happened after World War I. On the basis of the hopes and aspirations of mineral producers the Congress dismissed our deficient mineral problem with the imposition of a few tariffs, virtually all of which proved to be ineffective in the ensuing 15 years. As a result we came up to the second World War totally unprepared for the conflict.

The tariff has a lot to contribute to our present mineral position, but I don't by any means think that it is the only thing we should be doing at the present time.

Before we can reach any conclusions as to what can be expected from the development of these potential resources, particularly outside the United States, we need a lot more information.

On that point, I would like to say that one of my responsibilities in the Bureau of Mines is to try to gather factual data from all over the world on which to base judgments of this kind, and we are pitifully understaffed for that purpose.

The Nation's stake in the mineral resources of the world and the urgent need for accurate knowledge on what is going on in other parts of the world so as to help our own domestic industries are sufficient to justify a considerably larger effort in securing accurate and reliable information.

Senator MALONE. I want you to understand that one of the reasons before this committee men who are spending their lives in this field—one of the outstanding examples, I believe, is our witness on precious metals this afternoon—is that, in addition to their conclusion as to the possibilities of becoming self-sufficient in the United States or in the Western Hemisphere, I want to develop recommendations based upon their background of experience in the Bureau.

Of course, they worked in cooperation with their associates in the Bureau to determine not only what goals we might reach or which should be set as an objective, but what should be done specifically to reach those goals.

Sitting at this table in the last 7 years we have created pilot plants and set up laboratories and appropriated money for such specific purposes.

It is my belief that if this first-hand, down-to-earth, cold turkey information can be received from your Bureau as to what is necessary to do in laboratory experiments, investigations and examinations over a period of from 1, 3, 4, or 5 years, to bring about the desired objective, and if we can document this evidence before the Interior and Insular Affairs Committee, I am convinced the committee will make the proper recommendations to the Senate.

It is a very important thing that we not just listen to someone who has an objective entirely removed from self-sufficiency; that is, making friends out of some nation and adopting a policy of not entering into competition with this nation in the production of some metal or material for fear they will become aggravated and join some other nation. I think that is all poppycock.

It should be based right on the foundation of the national defense of this Nation and secondarily, but almost as important, to maintain our economic structure. We have to make up our minds that we want to do it on our present wage standard of living basis. If someone says frankly to me that we are living on too high a standard and that we should lower it to conform to other nations, I would have no quarrel with that gentleman. I merely disagree with his position; there would be no quarrel, because that is his idea. I only have a quarrel with people who say they want to maintain our wage standard of living and have free competition with the sweatshop labor of the world.

Mr. PEHRSON. I am quite sympathetic with the general notion that we should stimulate the production of those minerals in the Western Hemisphere for which we are now dependent on the Eastern Hemisphere, but I also realize there are many difficulties in obtaining that objective insofar as stimulating production outside the United States is concerned.

I would like to spend a few minutes discussing the various problems that we will be confronted with in that field.

The first one is how much will it cost? We just simply haven't got the data to answer this question. I think my colleagues in the Commodity Division will agree with me that we could not estimate what it would cost us to get this potential self-sufficiency in the Western Hemisphere where we do not have self-sufficiency now.

On the question of what it would cost, for example, to get the mica from Brazil we just do not have enough factual information to formulate sound judgments. We need to send engineers abroad to study these problems, and we need to do some analyzing here in Washington. We shall have to face the question ultimately of how much it will cost to get Western Hemisphere mineral expansion going.

One important factor in that cost is the inadequacy of transportation facilities almost every place outside of the United States. That is a very difficult problem, particularly when you get to dealing with the heavy tonnage minerals, such as manganese.

Also, in the Latin-American segment of the Western Hemisphere there is a very great scarcity of qualified technicians to achieve any great increase in production. If we wanted to get Brazilian manganese production going at an even greater rate than is now planned, the problem of qualified technicians for the job would have to be met.

Then there is the unfavorable climate for private capital. That opens up a Pandora's box of questions that we could discuss at considerable length, but for which we won't take time this afternoon. It will be sufficient to state for the record that generally speaking American capital is not interested in going into the Latin-American countries under present conditions. There are a few exceptions, but generally the climate for the kind of venture capital needed to accomplish the objective does not exist.

We have to consider also—and this again gets back to my fundamental premise that from a security viewpoint no mineral supply is good enough unless it is right here within the United States in time of war—that even if we are successful in stimulating production abroad how are we going to get it in time of war?

That raises another serious question: political availability. What could we guarantee under present conditions would be forthcoming from British Guiana, Guatemala, Bolivia, and Argentina, all of which have exhibited in recent years considerable hostility toward the United States? Even in the case of Canada there is a question of the possible neutrality at some future date. I think we could well afford to take advance measures so we would not have to be confronted with an embarrassing situation with our good neighbor north of us.

We also have the problem of sabotage. The discussion in the hearing so far has dealt almost entirely with the hazards of the sealanes but in addition to that there is the hazard of sabotage at producing centers.

If we can't keep Communists out of the citadel of secrecy at Monmouth, N. J., what chance have we got of preventing saboteurs from working in these isolated foreign producing centers, and it is not very difficult to knock out a vital part of a plant or an essential segment of transportation and hold up deliveries for a considerable period of time.

There has been emphasis on the hazards involved in supplies crossing the oceans, but let us not lose sight of the fact that 85 percent of the ships engaged in the bauxite trade with the northern coast of South America, right in our own front yard, were sunk before we got the submarine menace under control.

Also, let us not forget that military judgments in the field of raw materials are not infallible. We entered World War I and the record seems to indicate that practically no consideration had been given in advance to the problem of mineral supply. You are familiar with the hectic experience we had then. We came out of that experience only after many narrow escapes, yet the military again failed to give the rugged leadership they should have to this matter of security on the mineral front.

Again in World War II we were confronted with a submarine menace we had not anticipated, and it took us quite a little time to get it under control.

The Lord knows what surprises the enemy may have for us in the next war, so I will close with the parting statement that if we can get the material we must have from foreign countries into our country in advance of an emergency, then we have security. If we depend on outside sources of supply during war, we have little security because there are so many difficulties that can interrupt the trade.

In the long run we will save money if we buy these things and store them now, because after all, as you yourself have pointed out, Senator, the cost of convoying and protecting sealanes is terrific; the loss of life and ships is costly. As a long-range proposition the nonperishable strategic minerals that we need in our stockpile are going to appreciate in value. The limited nature of resources worldwide is going to cause an increase in price over the long run, and the carrying charges on the investment in the stockpile might well be offset, at least to some extent, by enhanced value.

Senator MALONE. Does that complete your statement?

Mr. PEHRSON. Yes.

Senator MALONE. I think you have made a very fine statement and one that can very well be heeded by individuals charged with the responsibility of stockpiling this material and by Congress in discharging its responsibility.

As a matter of fact, Congress has not discharged its responsibility, in my humble opinion, since 1934. I would like to ask you, if it doesn't cause you any embarrassment to express a personal opinion, whether you think that the Congress of the United States should reassume its constitutional responsibility of adjusting the duties and imports in order to carry out any policy that it might establish and in order to regulate foreign commerce?

Mr. PEHRSON. As far as strategic minerals are concerned, we should reestablish a policy of protection for domestic industry and I think a tariff is greatly to be preferred over any other method of subsidy.

Senator MALONE. That would mean, then, that the Congress of the United States would discontinue this glorious experiment of abrogating its constitutional responsibility to the President of the United States, to the executive department, to be carried out by the State Department, and reassume its responsibility to establish such protection.

Mr. PEHRSON. As I said earlier, Senator, I don't want to inject my viewpoints on the general subject of international trade because that is out of my field. But I will say that insofar as the mineral problem is concerned I think you are going in the right direction.

Senator MALONE. We thank you very much.

I would merely say to you that your department probably defined the terms strategic and critical materials.

I looked it up when I was special consultant to the Military Affairs Committee in the Second World War. A critical material is something that at the moment you are not producing enough of, and a strategic material is one emphasized, a little more at the time because it is a little scarcer.

Isn't that about right?

Mr. PEHRSON. Those are the old definitions. I think in recent years they have not retained that differentiation. They do, however, recognize orders of priority in the matter of stockpiling. Some minerals are designated as strategic and critical, but not for purchase purposes, merely for surplus transfers.

Another point that we want to remember is that when we were starting our stockpiling thinking in this country years ago we were concerned chiefly with protecting ourselves from the geographic hazard of foreign mineral supply, and all of these collateral problems of expanding domestic production and things of that kind had not yet come into play.

It is true that the Bureau of Mines has had a very vital part in the stockpiling program up until the Korean incident, but since that time the responsibilities, I believe, have shifted to other agencies.

Senator MALONE. My second observation or question, then: If strategic and critical materials are classed together and are not defined as to degree, they are materials which we do not produce in sufficient amount to meet our needs. Isn't that about it?

Mr. PEHRSON. That is correct.

Senator MALONE. Can't you make a strategic or critical material out of just about anything if you go far enough in encouraging sweatshop-labor competition from foreign nations? Even a certain kind of a textile might become strategic.

Mr. PEHRSON. As a matter of fact, we do have textiles on the strategic list right now; cotton and other fibers.

Senator MALONE. Many more might very well be made strategic, like the crockery business. We could very well call crockery strategic if we needed it in wartime and did not produce it, could we not?

Mr. PEHRSON. Yes.

Senator MALONE. That is a deliberate thing.

In other words, if we follow the policy of every nation producing what they can produce the cheapest, and our going out of that particular business, established by the State Department after Congress transferred its authority to fix the duties and import fees, to the logical conclusion, could not the list of strategic and critical materials be greatly enlarged?

Mr. PEHRSON. Not only that, but we would greatly enlarge the stockpile objective that we would have to accumulate.

Senator MALONE. Speaking as chairman of this committee, I appreciate very much your appearance here and your testimony. If you have any additional information you would like to furnish the committee, you are very welcome to do just that, and it will be included in the record.

Mr. PEHRSON. Thank you. If there is anything else that my part of the Bureau can do to furnish additional information, we will be only too happy to do so.

Senator MALONE. Thank you very much.

We will recess until 9:30 tomorrow morning.

(Whereupon, at 6:20 p. m., October 23, 1953, the hearing was recessed to reconvene at 9:30 a. m., October 24, 1953.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

SATURDAY, OCTOBER 24, 1953

UNITED STATES SENATE,
SUBCOMMITTEE ON MINERALS, MATERIALS AND
FULL ECONOMICS, OF THE COMMITTEE ON
INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to recess, at 9:30 a. m., in the committee room, 224 Senate Office Building, Washington, D. C., Senator George W. Malone, Nevada, chairman of the subcommittee, presiding.

Present: Senator George W. Malone, Nevada (chairman of the subcommittee).

Present also: Jerome S. Adlerman, counsel to the subcommittee; George B. Holderer, committee engineer.

Senator MALONE. The committee will be in order.

Mr. Irving, you know that the objectives of the committee are to determine the availability of the strategic and critical minerals and materials and fuels to the United States in wartime, and for our expanding economy and for our security.

STATEMENT OF DONALD R. IRVING, CERAMIC AND FERTILIZER MATERIALS BRANCH, BUREAU OF MINES

Mr. IRVING. Yes; I am familiar with that, Senator.

Senator MALONE. It is the opinion of the chairman, speaking as one member of the subcommittee, that our laboratory work and experiments for our expanding economy is extremely important, and of course for our national defense it is vital. Many military strategists of my acquaintance are of the opinion that we will have a very difficult time keeping the sealanes open across either ocean in the next war. So we are extremely interested in the opinions of the men who have spent their lives in study and investigations of these particular minerals and materials, and in their opinions as to what can be done to increase the production of such materials, in the United States, and to become self-sufficient in such production in the Western Hemisphere.

I was intensely interested in the chart prepared by your Bureau which lists such minerals under the headings of the United States actual, impending, and potential self-sufficiency, and grading of the supply of these materials in the order of their availability.

Then under United States, Canada, and Mexico, and the Western Hemisphere, actual, impending, and potential self-sufficiency, if these programs are carried out and technological changes permit use of

submarginal sources, and finally arriving at industrial diamonds being one in which we can be completely self-sufficient in this hemisphere, whereas now diamonds are entirely imported.

The testimony on these materials has been very encouraging.

Mr. Irving, I note quartz crystal and mica, which are minerals of known scarcity in the past, are listed, and I am very much interested in your opinion as to the availability of these materials. I would also appreciate receiving any general opinions or suggestions you can make to aid the committee in obtaining its objective.

CERAMICS AND FERTILIZERS

Mr. IRVING. Yes. For the purpose of the record, my name is Donald R. Irving. I am acting for W. F. Dietrich, Chief of the Ceramic and Fertilizer Materials Branch, United States Bureau of Mines. The commodities of the Ceramic and Fertilizer Materials Branch with which this hearing is concerned include potash, phosphate rock, nitrogen compounds, steatite talc for grinding, block steatite talc, jewel bearings, kyanite, graphite, mica, and radio-grade quartz crystal.

The United States has ample reserves of potash, phosphate rock, nitrogen compounds, and steatite talc for grinding to assure self-sufficiency for a long time.

Senator MALONE. That would be in your opinion the foreseeable future?

Mr. IRVING. Yes. I will expand on that later.

Dependence on high-grade imported kyanite can be eliminated by substitution of synthetic mullite at no higher cost. Except for mica, completion of programs now in progress should result in self-sufficiency in the remaining commodities within 2 or 3 years, although in some instances at considerably higher cost. Dependence on sources of mica outside of the Western Hemisphere will be greatly reduced.

I am including some commodities that are not on the strategic and critical list, because they are included on the chart, and for the record I thought it would be well to have a short statement concerning them.

Senator MALONE. I think it is very well to include them.

POTASH

Mr. IRVING. Potash. With over 88 percent of the domestic production of potash coming from the Carlsbad, N. Mex., area, the United States has in the last 25 years grown from being dependent on foreign producers to the second largest producer in the world. West Germany is the largest producer. The United States now exports sizable quantities of potash. Domestic deposits assure the United States of ample supplies of potash for more than 200 years and the newly discovered Canadian deposits, together with the domestic deposits, could make the whole Western Hemisphere self-sufficient for more than 300 years.

Senator MALONE. These are known deposits.

Mr. IRVING. Yes.

Senator MALONE. Not just proved reserves of 2, 3, or 4 years that are normally kept in good mining practice. These reserves are known.

Mr. IRVING. They probably include inferred reserves based on geologic evidence.

Senator MALONE. Estimated reserves.

Mr. IRVING. Yes. But in this particular type of deposit, it is much easier to estimate reserves than it is for some of the other commodities.

Better conservation through more efficient mining and processing would extend still further the life of the potash deposits in the United States and elsewhere in the Western Hemisphere.

PHOSPHATE ROCK

I will now take up phosphate rock. The United States is assured of complete self-sufficiency for several hundred years with no technologic advances, and for at least 1,000 years with the development of new mining and beneficiation techniques to permit utilization of the large lower-grade phosphatic shale deposits in the Western States.

With about 60 percent of the domestic reserves of phosphate rock in the Western States (Idaho, Montana, Utah, and Wyoming) this area is going to become increasingly important in future expansion of the phosphate industry. New mining and beneficiation techniques are needed to conserve and more efficiently utilize the resources of this highly valuable mineral.

NITROGEN COMPOUNDS

Nitrogen compounds. The reserves of nitrogen in the atmosphere assure the United States and all countries of endless supplies of nitrogen, with only the processing capacity likely to limit supply. Additional supplies of nitrogen compounds are obtained from coking plants and the natural nitrate deposits of Chile.

The problem of nitrogen compound supply is, therefore, not one of raw materials but of production facilities, which in war or mobilization periods may be inadequate to meet all requirements.

Senator MALONE. Let me ask you at this point, Mr. Irving, is not this a very good example of the results of laboratory work and experiments and inventions in substitution for the natural nitrogen compounds, or you might say the natural nitrogen deposits?

Mr. IRVING. Yes; it shows what necessity can force you to do.

Senator MALONE. We were at one time almost entirely dependent on the natural nitrogen deposits of Chile.

Mr. IRVING. That is right.

Senator MALONE. They had built their economy pretty much around these deposits.

Mr. IRVING. Yes.

Senator MALONE. Go ahead.

Mr. IRVING. I think there will be other instances in my statement that will give you a similar picture.

STEATITE TALC

Steatite talc for grinding. Reserves of steatite talc in the United States have been increased through recent discovery and development to the point of self-sufficiency is now assured.

The shortage in steatite grade talc which occurred at the beginning of World War II when only one mine in California supplied ground steatite talc for the manufacture of steatite ceramic insulators and tube spacers resulted in intensive exploration for new deposits and investigation by the Bureau of Mines of the properties of talc produced from numerous localities in the United States. The work disclosed that talc from a number of sources was satisfactory used alone or by blending, and that beneficiation of still other ores would produce concentrates that were acceptable. The information was published in Report of Investigation 3804 entitled "Survey of the Suitability of Domestic Talcs for High Frequency Insulators," April 1945. Recent development work on exceptionally large deposits of uniformly high-grade talc in Montana have further extended the reserves of steatite talc for grinding and assure the United States of self-sufficiency in this commodity.

I think this is one instance that proves the value of cataloging resources, a job which the Bureau of Mines is well able to do.

Another point which is brought out in the case of steatite talc for grinding is the fact that one of the largest of these deposits was discovered in 1951, showing that we have not yet found all of our resources.

Senator MALONE. Mr. Irving, is not that the history of all minerals, that when it becomes profitable to produce, discovery of the deposits just generally occurs. You certainly have a better chance of discovering them with men out looking for them.

When there is no profit in such discovery, there is just a drought of people looking for them, and as a result if a discovery is made it is just mostly through accident.

Mr. IRVING. Yes, that is right.

Block steatite talc. The material suitable for block steatite talc is a special type that can be machined, and which has certain other properties. The Western Hemisphere is completely lacking in reserves of block steatite talc. India and Italy are the sources of the mineral purchased for the national stockpile. Requirements during peacetime are small, but increase during war mobilization, especially for new designs of insulators and tube spacers for vacuum tubes.

Chemically bonded talc and synthetic mica products developed through research by the Bureau of Mines and industry will eliminate United States dependency on natural block steatite talc at a comparable cost, if service tests on their behavior under operating conditions prove satisfactory.

It is estimated that these tests will require 2 years for completion.

Senator MALONE. What is the outlook in your judgment?

Mr. IRVING. In my judgment, the tests will be successful. At least 1 of the 4 materials that we have available will be able to take care of the needs. Perhaps one of them will be good for some purposes and another one for other purposes.

Senator MALONE. Then we would be entirely independent in case of war and the normal channels of trade could proceed in peacetime.

Mr. IRVING. Yes. We have one difficulty in that we have carried our research to the end and have perfected these materials, but so far we have been unsuccessful in getting them evaluated.

The Signal Corps, whose main concern it is, has not been able so far to do very much in the way of evaluation. They are working at it from the angle of industry evaluation.

Senator MALONE. You mean the Signal Corps is not cooperating too well with you?

Mr. IRVING. No, they are cooperating, but they have a lot of places to put their money, and they have a lot of other projects that have high priority. It is something that I feel should be settled, because it is a vital point in the security of the United States.

Senator MALONE. In other words, you feel that the funds should be provided so that the Signal Corps can satisfy itself as to the efficiency of these products, that they are satisfactory substitutes.

Mr. IRVING. That is right. There is considerable controversy in industry and in Government agencies as to whether block talc is necessary or not. The fact remains that industry is ordering insulators manufactured from block talc and one company in the New York area has the larger proportion of its business in these machined block talc insulators.

We also know that when war comes there is a lot of electronic equipment on the drafting boards that probably would be brought out and the Signal Corps would immediately want rather rapid and expanded production of certain insulators and tube spacers.

Senator MALONE. If the experiments were accepted now it would prevent any necessity of a stockpile or worry in regard to the delivery in wartime.

Mr. IRVING. Yes.

Senator MALONE. I hope in your testimony some place you are estimating the tonnage required of these materials and their total value based on the experience over the years.

Mr. IRVING. That material is classified, Senator. It is not a large tonnage, relatively speaking.

Senator MALONE. In each case in these materials if anything is classified, treat it just as you are doing now, give us all the information you can. The amount of tonnage is classified?

Mr. IRVING. Yes. During World War II we were always just about to run out of block steatite talc and a large proportion of our requirements was flown in from India. In my longer statement I have stated that Indian material is preferable because it can be used for all applications. The Italian material cannot be used for ultrahigh frequency work.

Senator MALONE. But the substitute in your opinion can be used for all purposes?

Mr. IRVING. There is no way to make a definite statement on that. We have to make actual tests in vacuum tubes, that is receiving and transmitting tubes, to determine the unpredictable events that occur at high temperatures in a vacuum tube. You get molecular bombardment; you might get gasification.

Senator MALONE. But your opinion is that it has a fine chance of answering the purpose?

Mr. IRVING. Yes.

Senator MALONE. That is your professional opinion?

Mr. IRVING. I am a mining engineer, not an electronic engineer.

Senator MALONE. I understand, but you have had experience.

Mr. IRVING. It appears that we should have every chance of success. In the opinion of people that are experienced in the electronics industry that I have talked to, I have been assured of that.

Senator MALONE. Whereas the amount of such material might be classified, the cost would not?

Mr. IRVING. The cost is also classified.

Senator MALONE. All right. Just treat it like you do all classified material, give us all the information you can, and if it is necessary for us to go further, we can have an executive session.

Mr. IRVING. Yes. Here is a sample of built-up block talc made from ground steatite bonded with phosphoric acid.

Senator MALONE. Do you have a sample of the regular talc?

Mr. IRVING. I do not have a piece of the crude material, but I have a sample of Indian talc in the form of an insulator. These are the tube spacers or insulators that we were discussing. This one is machined from Indian block talc, and is unfired. This one is the same Indian block talc, fired. It is hard now, you see. The material has to have a certain amount of mechanical strength. This sample is machined from the phosphate-bonded talc.

Senator MALONE. Like this other piece of talc you just handed me.

Mr. IRVING. Yes.

Senator MALONE. Would it be possible under the classified information to furnish the committee samples on a card with some explanation of this material?

Mr. IRVING. We could do that.

Senator MALONE. I think it would be very helpful. You see, Mr. Irving, Senators and Congressmen have a lot of difficulties and trouble, in my opinion. We have sometimes too little time to discuss or spend on the main question. But if we can complete our record, and I think you are doing a fine job as each of your people who testified before have done, we cannot only have a complete record, but the committee can prepare findings and recommendations. If we have some samples of these very rare materials where we are transferring over to synthetic materials, for a quick look, I think it would be very helpful. So in every case such as this I suggest you encourage your people to furnish samples to the committee.

Mr. IRVING. Yes, I will be glad to do that.

Senator MALONE. Thank you.

Mr. IRVING. This is a sample of magnesium oxychloride bonded talc. It does not appear to be as good as the phosphate bonded. It is structurally less strong.

Senator MALONE. It still has more of the feel of the talc than the other.

Mr. IRVING. Yes. During World War II a shortage occurred of talc crayons for marking steel, partly, I think, because we did not have the men to mine the material. Magnesium oxychloride bonded talc could serve as a raw material for making talc crayons, if necessary, although it has not been thoroughly tested.

Senator MALONE. Probably if we planned ahead, which I hope we are doing at this time, for any emergency, we could better afford the

men to mine the material in this country or an adjacent country than we could afford the men and the ships to try to keep the transportation line open from India or Italy to get the material.

Mr. IRVING. Yes.

Senator MALONE. It would be less expensive in both lives and money. Go ahead.

Mr. IRVING. The outgrowth of our synthetic mica investigations at the Bureau of Mines, which I will discuss later, has produced a phosphate bonded mica that appears to be superior to block talc, and it may be the material that eventually replaces block talc. This is a sample of phosphate bonded synthetic mica.

Senator MALONE. What is that made out of?

Mr. IRVING. Synthetic mica.

Senator MALONE. Not the ground mica?

Mr. IRVING. Not ordinary ground mica, but synthetic mica ground and then bonded and reformed.

Senator MALONE. Such samples will be very interesting to the committee.

Mr. IRVING. Yes.

Senator MALONE. I have this in mind, Mr. Irving. You can explain the matter as you are explaining it to us, but if you actually see it, you know it is being done.

Mr. IRVING. Yes.

Senator MALONE. Go right ahead.

Mr. IRVING. I have a somewhat longer statement which I would like to submit for the record at this time. Included are some figures which will indicate the order of magnitude of the quantities needed. These figures were obtained from the Minerals Yearbook, and include some material that is not steatite block talc.

Senator MALONE. Then this text on block steatite talc, a summary, will be accepted and included in the record at this point as a part of your testimony.

(The information is as follows:)

BLOCK STEATITE TALC

SUMMARY

Block steatite talc is a massive, fine-grained variety of talc, low in impurities, such as iron, lime, and alumina, and capable of being easily sawed, drilled, milled, and lathe-turned to close tolerances. In addition, it must have suitable dielectric properties and uniform low shrinkage in all dimensions and low gas absorption when fired (baked) at a high temperature for seevral hours. It is used for special spacers and insulators in vacuum tubes for receiving and transmitting equipment in radar, radio, television, and other branches of the electronic industry.

Most types of tube spacers and insulators can be made by dry-pressing ceramic bodies either from ground steatite talc with a flux and a binder or from refractory alumina with a small quantity of flux. Insulators from these materials are mass-produced to fairly close tolerances, but when extremely close tolerances are specified machined block steatite talc is used. Also, because of the character of the machined surfaces, block steatite insulators, after firing, resist the formation of continuous electrical paths so satisfactorily that for some uses they are invaluable.

The important world sources of block steatite talc are Italy (Sardinia) and India. Italian material is not suitable for ultra-high-frequency uses; Indian material is suitable for all uses.

RESERVES

The Western Hemisphere is completely lacking in reserves of block steatite talc. During World War II a small quantity of block talc was produced from one deposit in Montana, but the quality was inferior to that of material obtained from either India or Italy mainly because of cracks that developed during firing.

SUBSTITUTES

Research by at least one private company and the Bureau of Mines has resulted in the development of 4 promising substitute materials utilizing domestic raw materials in ample supply; namely, (1) phosphate-bonded talc, (2) magnesium oxychloride-bonded talc, (3) hot-pressed synthetic mica, (4) phosphate-bonded synthetic mica.

All four of these new materials, on the basis of laboratory tests, possess suitable dielectric properties and strength, and all are machinable.

Tests to determine the behavior of these materials under the operating conditions in vacuum tubes still must be made and satisfactory performance by any one of them would eliminate United States dependency on uncertain foreign supply sources.

STRATEGIC CONSIDERATIONS

Except for the World War II years, 1942–44, inclusive, the United States has imported 100 percent of its requirements of block steatite talc. India has supplied by far the greatest proportion of this material and is the only source of superior-quality mineral. During a period of full mobilization, a number of special tube spacer and insulator designs must be put into immediate production to meet military demands, and block steatite talc requirements skyrocket at a time when imports from foreign overseas sources, such as India, become extremely uncertain. An interim objective of the national stockpile for block steatite talc has been contracted for, and no additional purchases are now contemplated. The need for complete evaluation of the substitute materials remains. It is estimated that it would require about 2 years to make the necessary tests.

Imports of "crude and unground" and "cut and sawed" talc, steatite, or soapstone, and French chalk into the United States for 1940–52, inclusive, are shown in the following table. The data contain some material of nonsteatite grade for some years.

TARIFF

Block steatite talc enters the United States duty free.

Talc—Imports of "crude and unground" and "cut and sawed" talc, steatite, or soapstone, and French chalk, by geographic sources, 1940–52 [1]

[In short tons]

	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
India	------	248	280	403	641	353	8	11	28	43	79	75	112
Italy	29	------	------	------	37	32	12	21	89	82	122	132	151

[1] U. S. Bureau of Mines, from records of the U. S. Department of Commerce.

JEWEL BEARINGS

Mr. IRVING. Next I will take up jewel bearings.

Most of the jewel bearings used in the United States are imported from Switzerland. The critical factors in establishing a jewel industry in the United States are high labor cost and a scarcity of skilled labor, and not a raw material shortage.

Senator MALONE. Now, Mr. Irving, you touched the nerve, I think. If the people of the United States complain of using their American wage standard of living to prepare the materials needed either for peacetime or war, it is time they reviewed their whole living standard structure. Many times you run out of the skilled labor by nonuse.

Would you care to make any suggestion as to how we eliminate a certain skilled labor in this Nation, or how it is possible to do it?

Mr. IRVING. I think the continuation of my statement will show a method of how to avoid completely running out of that skilled labor at a time when you need it.

Senator MALONE. Proceed with your statement. I would like again to call attention to the fact that in my earnest opinion the pressure to set up businesses abroad by American companies, and to furnish the machinery to the lower cost labor abroad stems from a definite movement in this Nation from two schools of thought. One school seeks to defeat the wage standard of living in this country by lowering it, and the other one, stemming from the 1934 Trade Agreements Act, seeks to make us dependent upon far-flung areas, mostly colonial slave nations, but in any case across one or both oceans, for the materials without which we cannot fight nor maintain our economic structure. I will be very much interested in your statement that explains that pretty angle.

Mr. IRVING. Yes. In the case of jewel bearings, we have never had an industry established in the United States. We have obtained our jewel bearings from Switzerland with the exception of minor quantities. In order to provide a nucleus of skilled workers that could be utilized in an emergency to train additional workers, thus permitting expansion of the domestic industry, a Government-subsidized plant was established near the Turtle Mountain Indian Reservation in North Dakota in 1952. The cost of jewels manufactured in this plant has been estimated at about five times that of imported jewels. Domestic security can best be achieved by having available an adequate stockpile of certain standard jewel bearings and special tools needed for their manufacture, and by relying on the expansion of production through utilization of the skilled labor and techniques gained through a subsidized industry during peacetime.

Senator MALONE. What is the principle you used in securing the labor you are training in these plants? Is it in the nature of apprentice labor that is being paid accordingly, and paid more as they become proficient, or how do you arrange the employment?

Mr. IRVING. This particular plant was located near the Turtle Mountain Indian Reservation because of a surplus of labor that it was thought would have the proper skills, dexterity, and whatever else was necessary to learn this trade.

Senator MALONE. That is Indian labor.

Mr. IRVING. Indian labor. However, there is no exclusion of anyone from going to work in the plant as far as I know.

Senator MALONE. But the surplus labor is mostly Indian labor.

Mr. IRVING. Yes. So it does provide employment for a certain segment of our population that might otherwise be without regular employment.

Senator MALONE. What are the wages paid, generally speaking, if you know? It is not important at this point.

Mr. IRVING. I do not know.

Senator MALONE. If you could, as a supplement to your statement, secure an explanation of how these men are employed, either on the basis of apprentice labor or merely unemployed labor, and what the future holds for these trained workers, I will appreciate it.

Mr. IRVING. Yes. I will be glad to do that, Senator.

(The information requested is as follows:)

Employees of the jewel bearing plant at Rolla, N. Dak., are receiving a basic hourly wage of 75 cents, the prevailing wage in that area. After a 14-week training period the wage is increased to about 80 cents. The labor supply consists of subsistence farmers and persons receiving relief. Each person is screened and graded for aptitude, skill, and finger dexterity before employment. There is low mobility of labor in the area, and if the plant were closed, the majority of the workers probably would return to subsistence farming or to the relief rolls. If the inertia to moving were overcome, employment might be obtained in the small jewel bearing industries in Mexico and Puerto Rico or skills gained at this plant perhaps could be applied in other industries found in nearby cities.

Mr. IRVING. That is a somewhat different approach to a problem of availability than most of our materials would come under, but actually the raw material for jewel bearings is a synthetic material and not a natural mineral.

Senator MALONE. If we approach the problem in a proper manner, there is no scarcity of material and should be no scarcity of labor.

Mr. IRVING. Yes. I will submit this longer statement for the record.

Senator MALONE. Jewel bearings text will be accepted as a part of your testimony, Mr. Irving, and included in the record at this point.

(The information is as follows:)

JEWEL BEARINGS

BACKGROUND

Jewel bearings made from natural or synthetic materials are used where it is necessary to minimize the friction between small moving parts. The tiny bearings, so small that 18,000 of the watch variety can fit in a thimble, find universal application in watches, gages, meters, indicators, fine scales and balances, time fuses, textile-thread guides, and other instruments. The common varieties of watch jewel bearings are cap, pallet stones, hole, and roller pins. Standard varieties of industrial jewel bearings are cup, vee, ring, and cap.

Jewel bearings manufactured from synthetic corundum, ruby and sapphire, largely have replaced natural mineral bearings. Synthetic spinel and glass also are used in making jewel bearings, but are limited to applications where maximum hardness is not essential. Synthetic corundum has chemical and physical properties identical to natural corundum, but is of greater purity, usually flawless, and less expensive. Bearings manufactured from synthetic sapphire are preferred for industrial applications; synthetic ruby bearings are preferred for watch jewels.

PRODUCTION

Domestic jewel bearing production has accounted for only a small portion of the annual consumption. Essentially, no watch jewels are made in the United States, except for a small quantity of pallet stones. The only jewel bearings manufactured domestically in any appreciable quantities are cup jewels. Statistics on jewel bearings are given in the accompanying table. Jewel bearings are manufactured at Waltham, Mass.; Trenton, Newark, and Perth Amboy, N. J.; Lancaster, Pa.; and Schenectady, N. Y.

Switzerland is the world's principal producer of jewel bearings both for watches and for industrial uses. Some jewel bearings are produced intermittently in Italy, France, and Germany, and during World War II, Russia and England produced limited quantities. In 1951, the value of Switzerland's jewel bearing production was approximately $14 million. Exports from Switzerland are as nonassembled jewel bearings and as a component of watch assemblies and watches. The manufacturing industry in Switzerland is controlled by a closely knit union organization and the foreign trade by a manufacturer's association which regulates prices and contracts of the watch jewel bearings. Industrial bearings are not subject to control.

IMPORTS

The major portion of the United States supply of jewel bearings has been imported, principally from Switzerland. Imports of jewel bearings are shown in the table.

FORECAST

During the past two decades, a definite trend to automatization and more complex instrumentation in industry has been evident. Military, as well as civilian, equipment requires a greater number of jewel bearings. Each new airplane has thousands of jewel bearings and large quantities are used in tanks, guided missiles, and rockets. New applications for jewel bearings will continue to develop as long as new and different devices are designed.

Jewel bearings are in group I on the United States list of critical and strategic materials. Three different classifications have been stockpiled, but purchases were suspended in 1950. If, at any time, the supply of jewel bearings from Switzerland were curtailed, the United States would be forced to resort to (*a*) a stockpile, (*b*) substitutes, or (*c*) a domestic industry. Although jewel bearings are readily stockpiled, there are hundreds of different shapes, sizes, and varieties, making it difficult to determine future requirements. Substitute materials, such as garnet jewels, glass jewels, or metal-on-metal, are of inferior quality and limited in their applications. So far, a commercially successful jewel bearing industry has not been established in the United States, but a jewel bearing pilot plant has been established near an Indian reservation at Rolla, N. Dak. Lack of labor skilled in making jewel bearings and competition from Swiss bearings of high quality through lower cost and plentiful supply have handicapped the domestic industry. Subsidization would be necessary to maintain an adequate industry in the United States. It appears that an ultimate goal will be obtained only through a coordinated program involving all three alternatives.

TARIFF

Tariff on jewel bearings is 10 percent ad valorem.

Jewel bearings—Domestic production, apparent consumption, and imports, 1940–52

(In thousands of jewels)

	1940	1941	1942	1943	1944	1945	1946
Domestic production [1]	[2]	3,500	13,872	17,369	13,610	1,232	1,874
Apparent consumption [3]	98,000	96,000	102,000	83,000	51,000	36,000	60,000
Imports: [4]							
Number of jewels	98,771	92,547	88,650	65,166	38,324	36,341	58,896
Value (thousands of dollars)	$1,851	$2,007	$2,771	$2,601	$1,377	$1,408	$2,076

	1947	1948	1949	1950	1951	1952
Domestic production [1]	2,627	2,576	2,725	3,327	9,877	[3] 11,000
Apparent consumption [3]	109,000	138,000	142,000	91,000	100,000	105,000
Imports: [4]						
Number of jewels	114,089	138,229	140,743	87,940	92,396	98,022
Value (thousands of dollars)	$4,016	$5,614	$5,117	$3,738	$3,966	$4,227

[1] U. S. Bureau of Mines.
[2] Not available.
[3] Estimated.
[4] Department of Commerce import statistics, jewels for any movements, mechanism, device, or instrument (dutiable under pars. 367 and 368) or any meter or compass.

KYANITE

Mr. IRVING. Kyanite. Although the United States has no known reserves of high-grade massive kyanite suitable for the manufacture of high-grade mullite refractories, research by Government and private concerns has resulted in the development of synthetic mullite products equal or superior to those derived from high-grade Indian kyanite at a cost no higher than that for the imported materials.

Stockpile objectives for kyanite and mullite have been achieved; and in view of assurance that acceptable mullite can be produced synthetically from Western Hemisphere sources, the United States can be considered self-sufficient in mullite-forming raw materials in the event of an emergency.

I have a somewhat longer statement to submit.

Senator MALONE. The text on kyanite will be accepted and appear in the record at this point.

(The information is as follows:)

KYANITE

The mullite-containing materials constitute one of the most important types of special refractories. Ninety percent of the domestic consumption of these materials is used in the metallurgical and glass industries and in high-temperature boilers. Mullite rarely is found in nature; but when any of the aluminum-silicate minerals, kyanite, andalusite, sillimanite, dumortierite, or topaz, are heated to an appropriate temperature, they are converted to a mixture of mullite and a form of free silica. Mullite of any desired purity also may be produced by sintering or fusing mixtures of alumina and kaolin or silica in the correct proportions.

Until recent years most of the mullite refractory material used in the United States was obtained by calcining high-grade massive Indian kyanite. Small quantities of massive kyanite also have come from Kenya and a few other localities. The kyanite from known domestic sources is not equivalent to Indian kyanite, principally because the domestic ore occurs as disseminated deposits and only can be recovered as fine concentrate. Hence, in analyzing kyanite-supply statistics to determine the quantity of strategic material available, the domestic component of supply must be eliminated from consideration.

During the last few years research by Government and private concerns has resulted in the development of synthetic mullite products equal or superior to those derived from high-grade Indian kyanite at no higher cost than for the imported material. Also, extra-high-quality synthetic mullite is produced from Bayer-process alumina using Caribbean bauxite. Mullite of excellent quality can be produced directly from certain domestic low-iron siliceous bauxite. Further investigations of domestic deposits of mullite-forming minerals are desirable.

Stockpile objectives for kyanite and mullite have been achieved; and in view of the assurance that acceptable mullite can be produced synthetically from Western Hemisphere sources, the United States can be considered self-sufficient in mullite-forming refractory raw materials in the event of an emergency.

TARIFF

Kyanite enters the United States duty free.

GRAPHITE

Mr. IRVING. Graphite. The United States depends on imports from Madagascar and Ceylon for its requirements of strategic graphite. All other grades of graphite can be supplied by domestic mines or overland routes from Mexico.

Self-sufficiency in times of emergency can be achieved by utilizing low-grade domestic ores, but at a cost of from 2 to 4 times the cost of imported material.

Senator MALONE. What is the cost of the imported material and the estimated cost of the domestic, if it were to be prepared in the volume which would be necessary if there were no imports?

Mr. IRVING. It is difficult to pick one price, because we have so many different grades of material coming in.

Senator MALONE. A range of prices would be even better.

Mr. IRVING. If I might, I would like to submit that a little later on this morning.

Senator MALONE. Very well.

Mr. IRVING. I can get it much better that way.

Tests by the National Bureau of Standards show that domestic flake graphite can replace Madagascar flake graphite in crucible manufacture.

General Services Administration, with technical assistance from the Bureau of Mines in mining and milling, is operating the Government-owned Benjamin Franklin mine and mill at Chester Springs, Pa., on an experimental basis, to obtain data on costs and to provide enough samples so industry can make large-scale evaluation tests. When operations are discontinued at the end of 1953, GSA will maintain the facilities in standby condition.

Strategic grades of graphite are being stockpiled to provide industry with its requirements during the interval required to bring domestic mines and mills into production. We should be able to obtain all the graphite we need during a war period.

Senator MALONE. Then the situation is simply one of cost and time required to go into production?

Mr. IRVING. Yes.

Senator MALONE. And your estimate is that the stockpile will maintain domestic needs during the interval the domestic product is coming into production?

Mr. IRVING. It remains for someone who has more information on the subject to determine the quantity that should be stockpiled.

Senator MALONE. Yes, of course, but there would not be any difficulty in stockpiling whatever is necessary, in your judgment?

Mr. IRVING. No. The present price of strategic graphite based on gross weight is $185 to $200 a ton, f. o. b. Madagascar. To this must be added, (1) an export tax of 2 percent on gross weight, which is equivalent to 3 percent on value, (2) costs of letters of credit, which vary with conditions and quantity, (3) a buyer's commission of 2 percent, (4) insurance of over $1 per ton, (5) handling charges in port, (6) tariff charges of $18.75 per ton, and (7) ocean freight. That would probably bring the price of this material to $300 per ton or perhaps a little higher. That would be an approximate figure.

Senator MALONE. At the moment, then, what would be the cost of our lower grade material?

Mr. IRVING. It would be from 2 to 4 times the cost of the imported graphite. We do not have exact figures.

Senator MALONE. From $600 to $1,200 a ton?

Mr. IRVING. Yes.

Senator MALONE. How many tons are we using?

Mr. IRVING. I have separately compiled the data on consumption of natural flake graphite for strategic uses, because I think only these uses would require this type of graphite. The consumption of natural flake graphite in the United States, 1948–52, for strategic uses,

ranged from a high of 11,942 short tons in 1951, to a low of 5,533 tons in 1949. Part of that great range is caused by the fact that in 1949 it was very difficult to get graphite, and the productive capacity just could not take care of the demand. That had been corrected by 1951. I would estimate the average consumption at about 7,500 tons per year.

Senator MALONE. That is very good.

Mr. IRVING. I have a longer and more complete statement on graphite.

Senator MALONE. The text on graphite will appear at this point in the record as a part of Mr. Irving's statement.

(The information is as follows:)

GRAPHITE

SUMMARY

Crucible-grade graphite

Graphite crucibles are used in foundries throughout the United States for melting various metals and alloys in electric, gas, coal, and oil furnaces. The strategic importance of crucible-grade graphite stems from the fact that American crucible manufacturers prefer special grades of flake graphite obtainable only in Madagascar.

Strategic material must meet rigid specifications as to the size of flakes and carbon content, essentially all coarser than 60-mesh and a carbon content of at least 85 percent. Some manufacturers use finer size material for making certain types of crucibles, especially those bonded with pitch instead of clay, but this finer graphite can always be obtained from the strategic grade.

Domestic deposits of flake graphite are extensive, particularly in Alabama, Texas, and Pennsylvania, but they are low grade and contain only small quantities properly sized for crucible manufacturing. Two privately operated mines and a Government-owned mine are producing flake graphite in the United States, none of which can produce over a few tons a month of crucible grade.

The present outlook for crucible-grade graphite shows that an ample supply will be available as long as communications with Madagascar remain uninterrupted. However, if United States supplies from Madagascar were to be cut off and dependence had to be placed on domestic production, the outlook would be extremely unfavorable. Domestic graphite equivalent to Madagascar material can be produced at high cost, but present facilities would permit production of only a few hundred tons per year at best.

Graphite crystalline fines

The term "crystalline fines" refers to crystalline flake graphite too fine in size for uses requiring relatively coarse flake material. In any flake-graphite deposit, the largest portion of the graphite is finer than 50-mesh, and only a relatively small part is coarser than 20-mesh. For certain uses, such as crucible manufacture, only the coarser flake is suitable, and the crystalline fines are to be avoided. Producers of flake graphite in Madagascar as well as the United States and other countries sell the large quantities of crystalline fines they produce along with the coarser material.

The crystalline fines imported from Madagascar to the United States compete with domestic graphite, largely of the same quality. These materials are used for many purposes, such as foundry facings, pencils, lubricants, and paints, none of which are strategically important because of the availability of various types of graphite which can be used for these purposes.

Amorphous-lump graphite

High-carbon amorphous-lump graphite is imported by the United States from Ceylon exclusively. High-purity Ceylon lump graphite containing 97- to 98-percent carbon is of strategic importance in the production of certain types of electric-motor brushes. These brushes are composed principally of petroleum coke plus certain additives, of which graphite is one. Hundreds of special types of motor brushes are made to fit special conditions. For example, it is claimed a brush designed to give optimum service on a diesel-electric locomotive operating on the Atlantic seaboard would not be satisfactory on the same locomotive if operated

under different conditions of temperature and humidity in the Middle West. The graphite content of the brushes is small, sometimes less than 5 percent, but it seriously affects the performance of the end product. Motor brushes for high-altitude airplanes are especially critical in time of war. Submarine motors are also important users of this type of graphite. Domestic flake graphite of sufficient purity might be a good substitute for the Ceylon material, but is not commercially available.

Lubricant- and packing-grade graphite

Graphite of all types is used in the United States for manufacturing various forms of lubricants. Flake graphite, free from abrasive impurities such as quartz, is preferred, as it readily forms a scaly layer on metal, whereas the amorphous type tends to flow excessively with the oil supplied to the bearing. It is also used for dry lubrication where oil or grease might be detrimental and where liquids of all sorts are to be avoided, as, for instance, on the bridges of pianos, organs, and textile machines.

Domestic graphite produced in Texas meets consumers' requirements for certain grades of lubricating graphite. For other grades, particularly those that must contain large-flake sizes, no commercial domestic supply is available, except from Alabama, Pennsylvania, and New York at extremely high-production cost. Madagascar flake graphite is the main source of the lubricating- and packing-grade graphite used in the United States.

Artificial or manufactured graphite is used also for lubricating purposes, usually under the trade name of Oildag or Aquadag. Artificial graphite seldom is used for the same lubricating purposes as the coarser natural-flake graphite; hence, it is not a substitute.

EUROPE

Seven countries in Europe have been producing graphite, but this is generally for domestic production, and only two have exported small amounts to the United States.

FEDERAL REPUBLIC OF GERMANY

There are important deposits of graphite in Germany in an area of about 500 square kilometers. The industry is controlled by a corporation which is conserving the resources and improving the technology of the operations.

The most important mine is in Bavaria. The ore contains 25- to 35-percent carbon. About 100 tons is treated daily in a modern flotation mill yielding 20 to 30 tons of concentrates with 90- to 98-percent carbon content. About 10 percent is flake graphite, and the rest is amorphous.

During 1952 this German industry exported 5,086 metric tons, of which 699 tons came to the United States. The imports are generally flake graphite.

AUSTRIA

Production has generally been about 20,000 metric tons yearly, but very little has come to the United States. With adequate mining and milling equipment, the output could be increased so as to supply the import requirements of the United States.

NORWAY

There is only one producing plant in Norway which has been producing about 2,500 tons of graphite a year. The domestic consumption is small, and most of the product is exported to other European countries.

STRATEGIC POSITION

The United States has never been self-sufficient with respect to graphite which has been classified as a strategic and critical material under the provisions of section 2 (a) of Public Law 520, 79th Congress. Under this law only high-grade amorphous lump such as that used for carbon brushes, lubricants, etc., and crystalline flake graphite suitable for crucibles, lubricants, and packings are considered strategic and critical. Lubricant and packing grade graphite is produced on a limited scale in the United States but high-grade amorphous lump and crucible-grade crystalline flake are entirely imported from Ceylon and Madagascar, respectively. All other grades of graphite can be supplied by domestic mines or imported over land routes from Mexico.

TARIFF

The United States tariff rates on graphite effective January 1, 1948, remained in effect during 1950. They are: Amorphous, natural and artificial, 5 percent ad valorem; crystalline flake, 15 percent ad valorem, with a specific minimum of 0.4125 cent per pound and a specific maximum of 0.825 cent per pound; crucible flake and dust and other crystalline lump and chip, 7½ percent ad valorem.

The consumption of natural flake graphite in the United States, for the major critical uses, 1948–52, are given in the attached table.

Important steps are being taken to insure the United States of self-sufficiency in times of emergency.

(1) Strategic grades of graphite are being purchased for the national stockpile.

(2) The National Bureau of Standards has compared the relative merits of crucibles manufactured from Alabama, Pennsylvania, and Madagascar graphite. The crucibles made from each variety of graphite were manufactured according to the formulas ordinarily used for the regular production of crucibles for use in brass-melting foundries, where the material is subject to great thermal shock. Six foundries were selected for making the tests and the crucibles were employed in the regular melting operations at the foundries. Conclusions reported[1] are that crucibles made from Madagascar flake graphite gave no more heats than crucibles manufactured with either Alabama or Pennsylvania graphite; carbon-bonded crucibles gave about twice as many heats as clay-bonded crucibles; and the use of finer flake sizes than ordinarily used by some manufacturers of carbon-bonded crucibles was not detrimental.

(3) Work was started in 1952 toward rehabilitating the Government-owned Benjamin Franklin mine and mill at Chester Springs, Pa., by the National Industrial Reserve Division of the General Services Administration. The Bureau of Mines is furnishing technical assistance in mining and milling. The mine and mill are being operated on an experimental basis to provide data on costs and to provide enough samples so that industry can make large-scale evaluation tests, thus paving the way to industry acceptance of domestic graphite. GSA plans to discontinue operations at the mine and mill before January 1, 1954, and thereafter maintain the facilities in standby condition.

Reserves of subcommercial flake graphite in the Western Hemisphere are adequate for emergency use, but at a cost from 2 to 4 times that of material imported from Madagascar and Ceylon. Figures showing the ratio of these subcommercial reserves to production and consumption are listed below:

	Reserves in terms of years of production	Reserves in terms of years of consumption
United States	60	27
United States-Canada-Mexico	55	30
Western Hemisphere	65	33

Consumption of natural flake graphite in the United States, 1948–52, for strategic uses, by uses

[In short tons]

Use	1948	1949	1950	1951	1952
Crucibles, retorts, stoppers, sleeves, and nozzles	3,655	3,043	3,615	5,435	3,275
Lubricants and packings	2,807	2,468	3,751	6,423	3,248
Bearings	26	22	46	84	80
Carbon brushes	(1)	(1)	(1)	(1)	805
Total	6,488	5,533	7,412	11,942	7,408

[1] Not available.

[1] Heindl, R. A., Effects of Graphite and Bonding Agents, Foundry Crucible Life: American Foundryman, Sept. 1952, pp. 40–43.

Imports of graphite for consumption in the United States, 1940–52, by geographic sources [1]

[In thousands of short tons]

	Crucible grade,[2] South Africa	Crystalline fines,[2] South Africa	Amorphous lump,[3] Asia		Crucible grade,[2] South Africa	Crystalline fines,[2] South Africa	Amorphous lump,[3] Asia
1940	(4)	(4)	(4)	1947	1.2	1.2	3.7
1941	(4)	(4)	(4)	1948	1.5	1.5	5.2
1942	2.9	2.9	9.0	1949	.9	.9	2.5
1943	2.5	2.5	.1	1950	2.8	2.8	6.0
1944	3.0	3.0	.2	1951	4.8	4.8	5.5
1945	1.4	1.4	.8	1952	[5] 5.0	[5] 5.0	[5] 5.7
1946	1.6	1.6	3.7				

[1] Bureau of Mines Minerals Yearbook.
[2] 50 percent of the crystalline, flake, imports from Madagascar.
[3] Imports of amorphous natural graphite from Ceylon.
[4] Not available.
[5] Estimated.

Consumption of natural graphite in the United States, 1947–52

	Quantity (in hundreds of short tons)		*Quantity (in hundreds of short tons)*
1947	17.4	1950	20.9
1948	20.8	1951	38.3
1949	16.3	1952	26.9

Senator MALONE. I want to congratulate you on the type of statements you have prepared. They are very welcome.

Mr. IRVING. Thank you.

MICA

Mica, startegic. The United States is virtually dependent on foreign sources, principally India, for strategic mica requirements. During World War II, only 4 percent of the strategic mica requirements were obtained from domestic sources despite subsidies of about 8 times the cost of imported mica. Through Defense Minerals Exploration Administration, the Government has established a program of exploration for strategic mica which provides assistance to miners on a participating basis, with the Government advancing 90 percent of the exploration costs. In July 1952 the Government, through GSA, initiated a long-range purchasing program to stimulate domestic production. Prices were established at 4 to 6 times the market price for imported mica. During the first 6 months of operation domestic production was at the rate of about 15 percent of the 1952 consumption rate of good stained and better mica. That is one of the better strategic qualities.

Senator MALONE. What are those prices, or will you cover that later?

Mr. IRVING. The prices established by General Services Administration, which would be the prices that are 4 to 6 times the market price, are as follows: Good stained and better, No. 3 and larger grade muscovite ruby mica, full trimmed, block and film, f. o. b. the Government depot—which would be Franklin, N. H., Spruce Pine, N. C., or Custer, S. Dak., $70 per pound; Nos. 4 and 5, $40 per pound; Nos. 5½ and 6, $15 per pound.

On stained quality, the prices for those three grades are $18, $8, and $5 per pound, respectively. For heavy stained, $13, $6, and $3, respectively. So we have a range from $70 for good stained and better, No. 3 and larger, to $3 per pound for Nos. 5½ and 6 heavy stained. Prices paid for nonruby muscovite mica are 20 percent less than for ruby mica of equivalent qualities and grades.

There are a number of other qualities and grades of mica and the price structure is rather complex, but that gives you the range of prices for the strategic material.

Senator MALONE. Is the complete story in the text you are to submit?

Mr. IRVING. No, but enough data are included to provide necessary background information.

Senator MALONE. What has been the consumption in pounds of the three different grades?

Mr. IRVING. The consumption figures are given in table 2 of the statement on mica. Consumption of muscovite block and film, United States, July to December 1952, by end uses, in pounds totaled 1,933,734 pounds.

Senator MALONE. Of the best grade?

Mr. IRVING. No; this includes all qualities.

Senator MALONE. Go ahead.

Mr. IRVING. Also, a table is included showing muscovite block and film, United States general imports, by qualities and principal sources, 1952.

Senator MALONE. That will be very satisfactory. Now, also the uses for mica are included in the general text?

Mr. IRVING. Yes.

Senator MALONE. Would you give us some general idea?

Mr. IRVING. Good stained and better mica for electronic uses, July-December 1952 totaled 171,443 pounds. Most of it was used for capacitors, some for tubes, a small amount for other electronic uses, and about 4,000 pounds for nonelectronic uses.

The total quantity of stained material, for electronic uses totaled 1,185,869 pounds for the same period.

Senator MALONE. All the details are in your table?

Mr. IRVING. Yes, sir.

Senator MALONE. $70 a pound is a good deal of money for a pound of mica or anything. What would you say would be the difference in the cost of the product in which $70 a pound mica was used as compared to product in which the imported mica was used?

Mr. IRVING. I doubt if it would be more than a few cents, at the most, for a particular tube or capacitor.

Senator MALONE. It is like tungsten and manganese in steel; it is a good deal like the soda in the biscuit; the cost is immaterial as far as the selling price of the completed product is concerned.

Mr. IRVING. Yes. A manufacturer, by paying $70 a pound, might be unable to operate profitably without raising his price, but the price per unit to the consumer would not be a great deal higher.

Senator MALONE. It would be comparable to tungsten and manganese and other products.

Mr. IRVING. Yes.

Senator MALONE. You see, sometimes a wrong impression is given to the public, that it is a terrible thing to have $40 a ton duty on copper, where, as a matter of fact, the article that they buy which

includes some of that copper has a difference in price that is infinitesimal. It has often been said that in trying to minimize the price of a dam they give the water stored behind it in gallons. To the engineers it is a joke, but to the public it is in billions and it looks like a good deal. I am only trying to show that it is a fact that in your work in preparing synthetic materials to displace imported materials in time of war, and also in the utilization of some of our lower grade materials, even if they were used in time of peace, there would be very little indication to the public in the price of the finished article.

Mr. IRVING. That might be possible. In a good many cases it probably is.

Senator MALONE. In most cases is it not a fact?

Mr. IRVING. It probably is.

Senator MALONE. Thank you.

Mr. IRVING. Under war economy, the consumption probably would be double the 1952 rate. The sporadic occurrence of sheet mica in pegmatites, the small size of the deposits, the quantity of mica that is rejected for structural defects, and the abnormally large proportion of hand labor required to successfully prepare the product for market all mitigate against successful operations in high-cost labor countries, which are forced to compete against countries like India, where the daily wage ranges from 21 cents for miners to a few cents for trimmers.

Senator MALONE. And here we pay $20 a day for miners, and then besides that, we have our unemployment insurance, social security and industrial insurance, which we should have. You put your finger right on the vital nerve. What many of these people are talking about is doing away with high-cost labor in these operations and using the sweatshop labor of 21 cents a day. Would you not believe 21 cents a day deserves the category of sweatshop labor?

Mr. IRVING. I have never been in India. I do not know what the rate would represent, but certainly it would not provide a high standard of living.

Senator MALONE. I have been to India. I judge from their actions that many of them do not know where they are going to sleep at night. A good many of them hardly know where their families are, or how they are going to eat, or what they are going to eat, and they do not eat a great variety of food as we do here. I think one of the things being developed in these hearings is that if we want to knock the standard of living down in this country, if we are dissatisfied with the standard for our workingman, we can do it very easily by using a low-cost or sweatshop labor of foreign countries. If we do not want to do it, then we need an equalizer. Whatever you care to call it, it is a good deal like a fellow said one time in watching a horseback rider; whether you stand up in the stirrups or sit on the saddle, the weight is still on the horse. So somewhere along the line you have to put your finger on it. You are doing it in a very—I might say—strategic manner.

Mr. IRVING. Brazil is second to India as a source of strategic muscovite mica, and in 1952 the United States obtained 30 percent of its imports of good stained and better block and film, and 69 percent of its stained block and film from this source. The mica industry in Brazil lacks modern equipment and technical management, and is further handicapped by high interest rates. As someone testified yes-

terday, Brazil also is beset by transportation difficulties. It is anticipated that production will decrease in the next few years unless the industry receives assistance. In an emergency Brazil could be an important source of strategic mica.

The Bureau of Mines, at Norris, Tenn., and industry have been conducting research in an effort to reduce United States dependence on imports of strategic mica through synthesis. Synthetic fluorine mica has properties superior to natural mica and reconstituted mica sheets of controllable thickness and uniformity have been produced that show promise as a possible substitute for sheet mica. Thus far it has not been possible to produce large crystals. Efforts to reduce the dependency of the United States on foreign sources of strategic mica should be concentrated on the following:

1. Intensified research on growing synthetic mica crystals, including fundamental studies on crystal defects and their correlation with the effect of physical-chemical environment on growth, together with further investigations for the control of crystallization.

2. Perfection of feasible and efficient methods for the delamination-relamination of synthetic flake mica for built-up mica, especially for electronic uses.

3. Encouragement of the expansion of free-world mica production, especially from Brazil, through technical assistance and a supply of equipment now not available to the miners, on a rental basis, or through financial assistance for purchase of such equipment.

4. Continuation of the evaluation of domestic mica resources with special reference to mining and processing techniques, economics, and potential recovery of coproducts and byproducts.

5. Continuation of mica purchases for the stockpile from domestic and foreign sources.

Strategic mica is the problem that most concerns the Ceramics and Fertilizer Materials Branch. We have good answers for all of the rest of the commodities in the foreseeable future, but synthetic mica research will probably have to be conducted for a good many years before we come up with the complete answer to the problem.

Senator MALONE. According to your testimony, with the synthetic products as the objective and very likely to be achieved within some reasonable time if they are prosecuted vigorously, with some foresight, you think the Western Hemisphere could become self-sufficient in the production of this important material for all uses.

Mr. IRVING. There is a good possibility of that in view of the fact that we got approximately 40 to 50 percent of our requirements last year from Brazil. There are large areas that are unexplored.

Senator MALONE. Dealing with producers in Brazil, then, on some long-range basis might be very helpful?

Mr. IRVING. I believe so.

Senator MALONE. At a price that would be profitable when they find it.

Mr. IRVING. Yes.

Senator MALONE. In that event, we would be self-sufficient in the Western Hemisphere where according to authorities, the transportation lines can be kept open.

Mr. IRVING. If we were not self-sufficient, we would certainly be a lot closer to it than we are now. It might be that small quantities

of the very highest qualities of mica would still have to come from India, but these could be brought in by plane or some other manner. Perhaps we could become entirely self-sufficient. Until World War II, the manufacturers in the United States were reluctant to use Brazil mica at all, because it was poorly prepared and they had no assurance of a continuity of supply, which is one of the essential things. Consumer resistance has been breaking down gradually. As it breaks down, we are more assured of a continuity of supply because it will be more profitable for men to produce mica.

Senator MALONE. It is probably just one of those things that the consumer had to have a dependable supply and the producer had to have a dependable market, and it had to be brought about through circumstances that did not exist for quite some time.

Mr. IRVING. Yes.

Senator MALONE. But now those circumstances do exist and there is a very great danger that supply lines from foreign sources from outside the Western Hemisphere will be cut in time of war.

Mr. IRVING. Yes.

Senator MALONE. Therefore, just like any other business, the demand is there, the market is there, the product is available, and it is only a matter of time until production is assured.

Mr. IRVING. Yes.

Senator MALONE. What about the experiments in sheet mica you are conducting?

Mr. IRVING. I will show you a sample of synthetic mica. That is the largest size of crystals we have been able to grow so far.

Senator MALONE. Do you have some of the regular mica?

Mr. IRVING. No; I did not bring any of the regular mica. Our experiments, as I say, in growing large crystals, have not been successful so far, that is, large crystals free from defects. This material is a fluorine mica. By using about 60 percent fluorine mica and 40 percent boron mica, which has a somewhat lower fusing point, we have been able to produce sheets with controllable thickness that give very good promise of being able to take the place of sheet mica. It is a little too early to evaluate the results, but we have good lines of approach to the problems.

Senator MALONE. In your judgment, there is every chance of success if the experiments are diligently pursued?

Mr. IRVING. That is right.

Senator MALONE. And in the reasonably near future?

Mr. IRVING. I was going to say it is hard to predict just when the right combination will be discovered but certainly in 5 years we should show tremendous progress, if not complete success.

Senator MALONE. Thank you.

Mr. IRVING. I have a text for the record.

Senator MALONE. I hope you can include the sheet mica in your exhibit.

Mr. IRVING. Yes.

Senator MALONE. The strategic mica text will be included at this point in the record.

(The information is as follows:)

MICA (STRATEGIC)

BACKGROUND

Mica is a group name of nine minerals differing in chemical composition and physical properties but characterized by perfect basal cleavage and ease of splitting into thin sheets. Only muscovite (potassium mica) and phlogopite (magnesium mica) have any significant commercial value, muscovite being of major importance.

Sheet mica, comprised of block, film, and splittings, is marketed in a variety of qualities, grades, and colors and is important in the electrical and electronic industries. The higher qualities of block mica and film mica are essential in the manufacture of certain capacitors and electronic tubes. Lower qualities of block mica, including punch and circle mica, are used in small electrical appliances. Mica splittings are used principally in making built-up mica, "micanite," by heating, pressing, and trimming alternate layers of mica splittings and a bonding agent. This mica board is used as insulating material in the electrical industry.

Pegmatite dikes are the only natural source of muscovite mica, but all pegmatites do not contain mica. In mica-bearing pegmatites, mica is distributed sporadically throughout the deposits as books or crystals of various sizes and thicknesses. It has not been possible to formulate criteria that will distinguish a productive pegmatite dike from a barren one or to establish the exact location of the mica within a productive dike. Thus, mining for strategic mica involves great financial risk.

UNITED STATES POSITION

The United States is the largest consumer of mica and is the world's largest producer when all classes of mica are considered. However, the United States produces only a small fraction of its requirements of high-quality sheet mica. Historically, punch and circle mica and scrap mica have been the dominant mica products in volume. Unfortunately, the electrical and electronic industries which are so essential to the highly mechanized way of life in the United States must rely upon foreign sources for most of the higher quality sheet mica. High labor costs and the high proportion of hand labor required to mine, process, and prepare sheet mica have restrained domestic exploration and mining. Usually, domestic producers can compete only through subsidization with foreign producers with low-cost labor, and sizable quantities of high-quality mica have been produced domestically only in emergency periods. During World War II, only ¼ percent of the strategic mica requirements were obtained from domestic sources despite subsidies of about eight times the cost of imported mica.

Mica has been produced sporadically in 25 States, but the major portion of the output has come from Connecticut, Georgia, New Hampshire, North Carolina, South Dakota, and Virginia. The most important domestic area, tonnagewise, is the Spruce Pine district in North Carolina, but approximately 90 percent of the mica is nonruby. Mica from South Dakota and New England is almost all ruby.

The United States Government, through DMEA, established a program of exploration for strategic mica which provides for financial assistance on a participating basis to owners and lessees of mineral properties with the Government advancing 90 percent of the cost. As of June 30, 1953, the agency had executed a total of 87 contracts for mica exploration at a total cost of $524,555. Of this number, 45 were terminated, canceled, or withdrawn and 42 were still in force. Only seven projects were issued certifications of discovery or development. Although the domestic program can be expected to result in some expansion of the domestic production of block and film mica, it is unlikely that it will result in a permanent improvement in the basic economics of sheet-mica mining in the United States.

In order to stimulate domestic production of strategic mica, the Government, through GSA, initiated a long-purchasing program. The program began in July 1952 and will be continued until June 30, 1955, or until the total block, film, and hand-cobbed mica accepted by the Government reaches the equivalent of 25,000 short tons of hand-cobbed mica or 2¼ million pounds of block or film mica. Depots were opened in Spruce Pine, N. C., Franklin, N. H., and Custer, S. Dak., for the inspection and purchase of mica. Prices for the mica ranged from $2 per

pound for Nos. 5½ and 6 half-trimmed heavy-stained to $70 per pound for No. 3 and larger full-trimmed good stained and better, about 4 to 6 times greater than the market price. As of December 31, 1952, a total of 55,515 pounds of full-trimmed mica was purchased, 66 percent of which originated at the Spruce Pine depot. Of the total poundage, about 26,663 pounds was good-stained and better quality, 23,859 stained, and 4,993 heavy-stained.

TABLE 1.—*Yield of full-trimmed mica from domestic purchases by GSA, July–December 1952, by quality, grade, and depot*

[In pounds]

Grade and depot	Total	Good-stained and better	Stained		Heavy stained	Other	Punch	Scrap
			A	B				
Spruce Pine, N. C.:								
2 and L	200.26	149.41	22.94	11.88	16.03			
3	437.91	295.90	79.36	32.78	29.87			
4	1,565.40	958.61	361.78	131.04	113.97			
5	6,500.17	4,045.18	1,556.30	514.43	384.26			
5½	5,326.85	3,180.51	1,363.93	465.60	316.81			
6	22,800.14	13,840.95	5,850.27	1,859.70	1,249.22			
Total	36,830.73	22,470.56	9,234.58	3,015.43	2,110.16	196.26	296.05	43.19
Franklin, N. H.:								
2 and L	36.72	6.44	9.77	12.31	8.20			
3	110.17	27.08	46.56	26.17	10.36			
4	286.54	81.96	121.01	62.23	21.34			
5	959.55	326.40	383.85	191.98	57.32			
5½	757.39	255.47	310.06	156.86	55.00			
6	2,138.39	782.81	880.67	373.99	100.92			
Total	4,288.76	1,480.16	1,751.92	823.54	233.14	1,765.01	933.23	1,581.14
Custer, S. Dak.:								
2 and L	121.38	24.88	84.31		12.19			
3	312.05	50.06	227.87		34.12			
4	1,044.00	225.12	708.88		110.00			
5	4,008.19	816.38	2,599.94		591.87			
5½	2,347.50	385.19	1,481.06		481.25			
6	6,562.25	1,210.37	3,931.50		1,420.38			
Total	14,395.37	2,712.00	9,033.56		2,649.81		30,353.50	50,905.88
Grand total	55,514.86	26,662.72	23,859.03		4,993.11	1,961.27	31,582.78	52,530.21

The Government also has extended purchase contracts for imported mica, including several with Brazilian producers.

The Bureau of Mines, in cooperation with NPA, initiated a quarterly canvass on mica consumption, in order to obtain data not previously available for defense mobilization planning. Industry reported a consumption of 175,821 pounds of good-stained and better mica from July to December 1952. At this rate, only 15 percent of the 1952 consumption of good-stained and better mica could have been supplied by the subsidized domestic mica program and under a war economy consumption probably would be double the 1952 rate. Consumption of stained mica was 1,259,591 pounds and lower than stained was 1,933,734 pounds.

Government and industry have been conducting experiments on mica in an effort to alleviate the shortage of strategic grades and qualities of muscovite sheet mica. The objective of the Bureau of Mines program at Norris, Tenn., since 1947 has been to fabricate and study synthetic fluorine-mica ceramics and to investigate methods for growing crystals and fabricating sheets of synthetic fluorine-mica. Major accomplishments have been (1) development of the direct electric resistance melting technique of manufacturing large quantities of flake mica, (2) synthesis of fluorine-micas by solid-state reaction, (3) development of machinable synthetic mica ceramic dielectrics by hot-pressing and phosphate bonding, (4) invention of synthetic mica-metal cermets and a reconstituted synthetic mica sheet, and (5) discovery of a family of synthetic clay-like compounds that are potential catalysts and bleaching agents.

TABLE 2.—*Consumption of muscovite block and film in the United States, July-December 1952, by end uses*

[In pounds]

Block and film	Quantity (pounds)	Percent of grand total	Percent of quality
Good-stained and better: [1]			
Electronic, total	171,443	8.9	97.5
Capacitors	107,813	5.6	61.3
Tubes	62,395	3.2	35.5
Other	1,235	.1	.7
Nonelectronic	4,378	.2	2.5
Total	175,821	9.1	100.0
Stained: [2]			
Electronic, total	1,185,869	61.3	94.1
Capacitors	14,989	.8	1.2
Tubes	1,161,648	60.0	92.2
Other	9,232	.5	.7
Nonelectronic	73,722	3.8	5.9
Total	1,259,591	65.1	100.0
Lower than stained:			
Electronic, total	131,096	6.8	26.3
Capacitors	185	(3)	(3)
Tubes	126,848	6.6	25.5
Other	4,063	.2	.8
Nonelectronic	367,226	19.0	73.7
Total	498,322	25.8	100.0
Grand total	1,933,734	100.0	

[1] Includes 1st- and 2d-quality film.
[2] Includes other quality film.
[3] Less than 0.1 percent.

Experiments have shown that replacement of the OH ion with F gives synthetic mica superior properties to natural mica and can withstand higher temperatures. The composition of the synthetic mica can be controlled with virtual elimination of iron and other contaminates that lower the Q-factor. A high Q-factor is desirable in a material used in capacitor circuits. Results show that hot-pressed synthetic mica is comparable to the best commercial ceramic dielectrics. There has been increased interest by industry in this material as a matrix for silicon carbide and as a mica ceramic for jet engines. Reconstituted mica sheets of controllable thickness and uniformity have been produced from synthetic mica and show promise as a possible substitute for sheet mica. The mechanical strength of such sheets has been improved significantly by bonding normal fluor-phlogopite mica to boron-phlogopite mica. Recently, a company advertised the availability of synthetic mica in trial and semiproduction lots. The production of this material was a direct outgrowth of the Bureau of Mines program on synthetic mica.

Recent developments by two commercial firms permit the use of domestic scrap mica in the production of reconstituted mica in long continuous sheets or rolls. This new product provides the electrical designer with a new and improved electrical insulation for applications now using built-up mica, made with imported splittings. Further development of this material may relieve our country of its dependence on India for our annual supply of splittings. However, in order for the Indian mica industry to operate profitably, a market must exist for the splittings obtained in the preparation of block and film mica, or the prices of block and film mica would have to be increased.

STOCKPILE

The following categories of mica are being stockpiled: Muscovite block, good stained and better; muscovite block, stained; muscovite film; phlogopite block;

muscovite splittings; and phlogopite splittings. The objective has been met for both varieties of splittings. Purchase of the other classes is continuing to meet the established objectives.

RESERVES

Because of the sporadic nature of the mica deposition, it is almost impossible to estimate reserves of strategic mica in the Western Hemisphere. The best reserve estimates show the northern section, principally the United States and Canada, to be bad in reserves. Brazil has the best reserves in the Western Hemisphere, but can only be classified as slightly better than bad.

IMPORTS

The United States depends on foreign sources for high-quality sheet mica. Most strategic muscovite mica block, film, and splittings imports into the United States have come from India.

Brazil is second to India as a source of strategic qualities of muscovite. Many authorities on the mica industry consider it potentially as important as India. The best known and most accessible mica-producing areas in Brazil are in the State of Minas Geraes. Import records show that the United States imported from Brazil 197,768 pounds of good stained and better block and film and 1,389,311 pounds of stained in 1952. This represented 30 and 69 percent, respectively, of the total United States imports. Mica imports from Brazil are averaging $13.50 per pound for good stained and better mica, as against $27 for good stained and better domestic mica sold to the Government. The mica industry in Brazil is very primitive and lacks modern equipment and technical management, and is further handicapped by high interest rates. It is anticipated that mica production in Brazil will decrease in the next few years unless aid is given to the mica industry. In an emergency, Brazil could serve as a vital factor in our supply of strategic block and film mica.

TABLE 3.—*Muscovite block and film mica, United States general imports, by qualities and principal sources, 1952* [1] [2]

[Quantity in pounds]

Quality	Total	Countries		
		India	Brazil	Other [3]
Block:				
Good stained and better	352,237	117,589	197,459	37,189
Stained	2,019,543	599,870	1,389,055	30,618
Heavy stained	573,227	37,933	524,757	10,537
Lower	665,601	118,291	510,006	37,304
Total	3,610,608	873,683	2,621,277	115,648
Film:				
1st quality	101,394	101,363		31
2d quality	196,809	196,360	330	119
Other	4,167	3,932	235	
Total	302,370	301,655	565	150
Block and film:				
Good stained and better [4]	650,419	415,312	197,768	37,339
Stained [5]	2,023,731	603,802	1,389,311	30,618
Heavy stained	573,227	37,933	524,757	10,537
Lower	665,601	118,291	510,006	37,304
Total	3,912,978	1,175,338	2,621,842	115,798

[1] Compiled by the U. S. Tariff Commission from official documents of the U. S. Bureau of Customs.
[2] Does not include imports from Angola, Austria, Port of East Africa, and Northern Rhodesia because detailed breakdowns from these sources are not available. Imports from these sources totaled 48,350 pounds.
[3] Includes imports from Angola, Argentina, Canada, Colombia, Southern Rhodesia, Tanganyika, and United Kingdom.
[4] Includes 1st and 2d quality film.
[5] Includes other quality film.

TABLE 4.—*Muscovite splittings, United States general imports, by form and principal sources, 1952* [1]

[Quantity in pounds]

Country	Total	Form		
		Book	Loose	Loose dusted
India	6,759,201	894,916	4,843,051	1,021,234
Other [2]	16,600	5,691	10,756	153
Total	6,775,801	900,607	4,853,807	1,021,387

[1] Compiled by the U. S. Tariff Commission from official documents of the U. S. Bureau of Customs.
[2] Includes imports from Brazil and Mexico.

TABLE 5.—*Phlogopite splittings, United States general imports, by principal sources, 1952* [1]

Country:	*Quantity*
Madagascar	677,688
Other [2]	1,084
Total	678,772

[1] Compiled by the U. S. Tariff Commission from official documents of the U. S. Bureau of Customs.
[2] Includes imports from Canada and Mexico.

TARIFF

Depending on state of manufacture and size, duties range from 2 cents per pound plus 15 percent ad valorem up to 40 percent ad valorem.

Efforts to reduce the dependency of the United States on foreign sources of strategic mica should be concentrated on the following:

1. Intensified research on growing synthetic mica crystals, including fundamental studies of crystal defects and their correlation with the effect of physical-chemical environment on growth, together with further investigations for the control of crystallization.

2. Perfection of feasible and efficient methods for the delamination-relamination of synthetic flake mica for builtup mica, especially for electronic uses.

3. Encouragement of the expansion of free-world mica production, especially from Brazil, through technical assistance and a supply of equipment now not available to the miners, on a rental basis, or through financial assistance for purchase of such equipment.

4. Continuation of the evaluation of domestic mica resources with special reference to mining and processing techniques, economics, and the potential recovery of coproducts and byproducts.

5. Continuation of mica purchases for the stockpile from domestic and foreign sources.

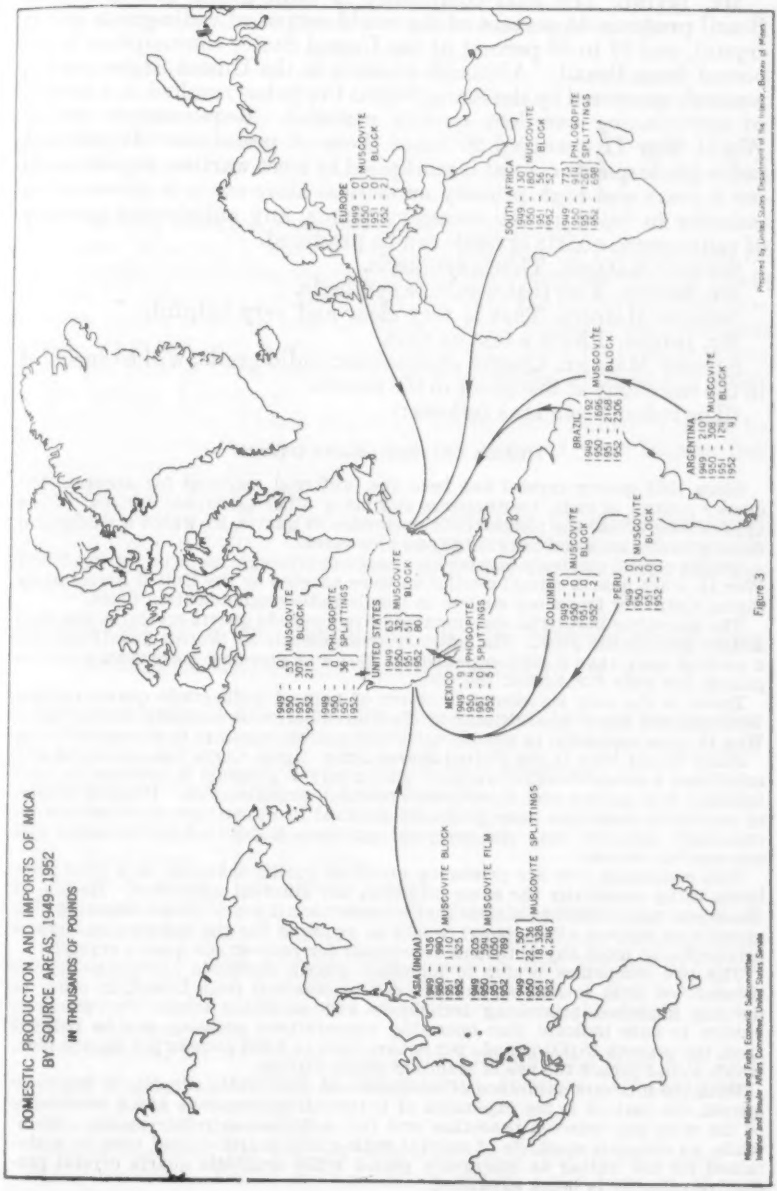

DOMESTIC PRODUCTION AND IMPORTS OF MICA
BY SOURCE AREAS, 1949-1952
IN THOUSANDS OF POUNDS
INDIA
1949 - 838
1950 - 990
1951 - 1110
1952 - 525
1949 - 593
1950 - 1051
1951 - 1050
1952 - 789
1949 - 17,307
1950 - 28,136
1951 - 8,335
1952 - 6,246
MUSCOVITE BLOCK
MUSCOVITE FILM
MUSCOVITE SPLITTINGS
UNITED STATES
1949 - 0
1950 - 307
1951 - 215
1952 -
1949 - 1
1950 - 36
1951 -
1952 -
MUSCOVITE BLOCK
PHLOGOPITE SPLITTINGS
UNITED STATES
1949 - 11
1950 - 32
1951 - 51
1952 - 80
MUSCOVITE BLOCK
MEXICO
1949 - 9
1950 - 0
1951 - 0
1952 - 5
PHLOGOPITE SPLITTINGS
COLUMBIA
1949 - 0
1950 - 0
1951 - 0
1952 - 2
MUSCOVITE BLOCK
PERU
1949 - 0
1950 - 0
1951 - 0
1952 - 0
MUSCOVITE BLOCK
EUROPE
1949 - 0
1950 - 0
1951 - 0
1952 - 2
MUSCOVITE BLOCK
SOUTH AFRICA
1949 - 130
1950 - 663
1951 - 1
1952 - 52
MUSCOVITE BLOCK
1949 - 773
1950 - 910
1951 - 698
1952 -
PHLOGOPITE SPLITTINGS
BRAZIL
1949 - 1192
1950 - 1676
1951 - 2168
1952 - 2306
MUSCOVITE BLOCK
ARGENTINA
1949 - 210
1950 - 326
1951 - 176
1952 - 4
MUSCOVITE BLOCK
Prepared by United States Department of the Interior, Bureau of Mines
Minerals, Materials and Fuels Economic Subcommittee
Interior and Insular Affairs Committee, United States Senate

Figure 3

QUARTZ CRYSTAL (RADIO GRADE)

Mr. IRVING. The final commodity is radio-grade quartz crystal. Brazil produces 95 percent of the world output of radio-grade quartz crystal, and 97 to 98 percent of the United States consumption is imported from Brazil. Although reserves in the United States are nil, research sponsored by the Army Signal Corps has resulted in a method of synthesizing excellent quality material. Requirements during World War II averaged 20 times those of peacetime. If sufficient radio-grade quartz crystal is stockpiled to meet wartime requirements for 2 years and high priority on critical alloy steels is given to the industry to build up the necessary plants, any anticipated quantity of radio-grade quartz crystals can be produced.

Senator MALONE. This is synthetic.

Mr. IRVING. Yes; that would be synthetic.

Senator MALONE. That is very clear and very helpful.

Mr. IRVING. I have a text on that.

Senator MALONE. Quartz-crystal text, radio grade, will be included in the testimony at this point in the record.

(The information is as follows:)

QUARTZ CRYSTAL (RADIO GRADE)

Since 1921 quartz crystal has been the preferred material for accurate frequency control in radio transmitters and many other electronic devices. These applications utilize the piezoelectric properties of quartz, by which a mechanical force produces an electrical charge and vice versa.

Quartz crystal suddenly became an important strategic material during World War II, when quartz-crystal oscillators were adopted by the United States Army Signal Corps for frequency control in mobile radio-communication units.

The peacetime industrial consumption of radio-grade quartz crystal is less than 100,000 pounds per year. The military requirements in World War II reached a peak of more than 3 million pounds in 1943 and averaged more than 2 million pounds per year throughout the war.

Brazil is the only significant producer of natural radio-grade quartz crystal. Technical and financial assistance by the United States Government during World War II were successful in procuring enough quartz crystal to meet requirements.

Since World War II the United States Army Signal Corps has sponsored and subsidized a comprehensive synthetic quartz-crystal program in cooperation with industry and private and Government research organizations. Parallel studies of substitute materials have gradually declined in importance as it became increasingly apparent that quartz-crystal synthesis is destined for technical and commercial success.

Two companies now are producing excellent quality material on a pilot-plant basis, using essentially the same principle, but different apparatus. Results of these pilot-plant studies indicate that no more than 2 years' time (assuming high priority on critical alloy steels) would be required for the industry to expand production to meet any anticipated demands for radio-grade quartz crystal.

The two companies prefer to maintain quartz synthesis operations at the present low level so long as supplies can be obtained from Brazil, in order to develop improved processing techniques and ascertain costs. For example, studies to date indicate that operating temperatures probably can be reduced from the present 15,000 pounds per square inch to 1,500 pounds per square inch, which would permit the use of standard steam fittings.

With the ultimate assurance of adequate and dependable supplies of synthetic quartz, the outlook is for expansion of industrial applications and a narrowing of the wide gap between peacetime and full mobilization requirements. Meanwhile, an adequate stockpile of natural radio-grade quartz crystal must be maintained for use during an emergency period while synthetic quartz crystal productive capacity is being expanded.

TARIFF

Quartz crystal enters the United States duty-free.

Radio-grade quartz—Domestic consumption and imports, 1948–52

[In thousands of pounds]

	1948	1949	1950	1951	1952
Domestic consumption	61.6	46.2	114.3	282.3	502.5
Imports, Brazil	1,205.9	289.3	216.9	829.2	1,017.6
Average import price, per pound	$3.43	$4.76	$3.26	$2.43	$2.75

Mr. IRVING. Senator, that concludes my testimony.

Senator MALONE. I want to congratulate you on the clearness of your description of these important materials, both the natural product and the substitute products, together with the status of their production in this country, and the source of the material we have been using. It is just such work as you are doing, in my opinion, that can make this Nation independent and able to defend itself at any time.

Mr. IRVING. Thank you.

Senator MALONE. Thank you very much. Mr. Zinner, I want to take this occasion to say to you that the work of your Bureau has certainly been very satisfactory.

Mr. ZINNER. Thank you.

Senator MALONE. We have G. W. Josephson, Chief, Construction and Chemical Materials Branch. I suggest you be the next witness. Will you identify yourself for the committee record and describe the field that you cover?

STATEMENT OF G. W. JOSEPHSON, CHIEF, CONSTRUCTION AND CHEMICAL MATERIALS BRANCH, BUREAU OF MINES

Mr. JOSEPHSON. I am G. W. Josephson, Chief of the Construction and Chemical Materials Branch of the Bureau. I have statements on seven commodities, ranging from iodine to asbestos.

Senator MALONE. That includes cryolite?

Mr. JOSEPHSON. Yes; and a number of others.

Senator MALONE. Diamonds and fluorspar?

Mr. JOSEPHSON. That is right.

Senator MALONE. Will you proceed?

Mr. JOSEPHSON. I have a relatively short statement for each of these, and an expanded version which I gather from talking with members of your staff this morning might be well for me to retain for the time being if it is your desire. Otherwise, I can turn it in now, and it can be made a part of the record and the detail can be worked out next week.

I understand Mr. Holderer would like to determine later how this material is to be presented in the record. Is there any particular procedure that you prefer?

(Discussion off the record.)

Senator MALONE. Do you not have a complete text on each one?

Mr. JOSEPHSON. Yes; I have a version which I can turn in, if you wish. It is up to you.

Senator MALONE. I think that you better read your statement and turn in the completed text subject to a completion and editing and correction.

IODINE

Mr. JOSEPHSON. That is fine. First, we will touch upon iodine. Iodine has been produced commercially from such widely diverse sources as seaweed, oil-well brines, and nitrate deposits.

Iodine and its compounds have a number of essential uses. Probably the best known application is as an antiseptic. Another important medical use is for the control of goiter. For this purpose it is generally used in the form of iodized salt with which nearly everyone is familiar. It is also added to stock feeds for use in areas that are naturally deficient in iodine. One important industrial use is in photographic film and it has numerous other applications throughout industry and in the medical field.

At the present time three of the major iodine production centers are in Chile, the United States, and Japan. In Chile it is a byproduct of nitrate recovery and in both Japan and the United States it is obtained from natural brines. Production statistics are not published for the United States because there are only two firms involved and publication of the total would reveal individual company figures. Output in Chile generally ranges from a million to more than 3 million pounds per year. Operators in the area have indicated that the output could be increased substantially over this level if the need were to arise. In 1952 production in Japan was estimated at about 660,000 pounds.

Presently the United States imports iodine from both Chile and Japan.

Imports tend to be variable from year to year because substantial stocks are held in the United States and are replenished from time to time. In recent years the United States has obtained roughly one-half of its supplies from foreign sources. Present sources can easily supply all United States requirements.

If in time of war only the Western Hemisphere were accessible, our essential requirements could be satisfied from Chilean and domestic sources. Reserves in Chile are large but it must be borne in mind the commodity is a byproduct of nitrate production and therefore the production of iodine depends upon the continued production of nitrate.

If for some reason Chile were no longer accessible as a supplier, it is believed that it would be possible to increase domestic production sufficiently to provide for the strategically essential requirements. No estimates of iodine reserves in the United States are available, but they apparently are adequate for many years of production at present or at any accelerated rate that is anticipated as necessary in a time of emergency.

There appears to be sufficient flexibility in the iodine supply potential to permit adjustment to almost any emergency situation. This is particularly true if an adequate stockpile is maintained as insurance

against the possible shortages that might result from cutting off foreign sources and damage to production facilities.

Senator MALONE. The text on iodine will be accepted and appear in the record at this point as a part of Mr. Josephson's testimony.

(The information is as follows:)

IODINE

Iodine has been produced commercially from such widely diverse sources as seaweed, oil well brines, and nitrate deposits.

Iodine and its compounds have a number of essential uses. Probably its best known application is as an antiseptic. Another important medical use is for the control of goiter. For this purpose it is generally used in the form of iodized salt with which nearly everyone is familiar. It is also added to stock feeds for use in areas that are naturally deficient in iodine. One important industrial use is in photographic film and it has numerous other applications throughout industry and in the medical field.

Exact statistics on the quantities consumed in each of the uses are not available but the following table shows the quantities of crude iodine consumed in the production of the various compounds.

TABLE 1.—*Crude iodine consumed in the United States in 1950–52*

Compound manufactured	1950			1951			1952		
	Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Pounds	Percent of total		Pounds	Percent of total		Pounds	Percent of total
Resublimed iodine	5	145,534	11	6	137,918	11	5	78,222	7
Potassium iodide	8	1,014,940	73	9	787,936	64	10	768,554	65
Sodium iodide	5	59,818	4	5	114,307	9	6	64,332	5
Other inorganic compounds	7	57,705	4	8	45,198	4	8	29,785	3
Organic compounds	12	114,148	8	16	152,563	12	13	232,981	20
Total	[1] 22	1,392,145	100	[1] 25	1,237,922	100	[1] 25	1,173,874	100

[1] A plant producing more than 1 product is counted but once in arriving at total.

At the present time three of the major iodine production centers are in Chile, the United States, and Japan. In Chile it is a byproduct of nitrate recovery and in both Japan and the United States it is obtained from natural brines. Production statistics are not published for the United States because there are only two firms involved and publication of the total would reveal individual company figures. Output in Chile generally ranges from a million to more than 3 million pounds per year. Operators in the area have indicated that output could be increased substantially over this level if the need were to arise.

Japan has long been a source of iodine. For many years it processed seaweed but since 1935 the trend has been toward the recovery from brines. The gradual decline of seaweed iodine output to virtually the point of extinction has been more than offset by the growth of output from brines. In 1952 production in Japan is estimated at about 660,000 pounds.

Presently the United States imports iodine from both Chile and Japan. The following table shows our imports from these countries during the period 1939–52.

Crude iodine imported for consumption in the United States, by countries of origin, 1939–51

Year	Chile		Japan		Total	
	Pounds	Value	Pounds	Value	Pounds	Value
1939	200,000	$168,238			200,000	$168,238
1940	1,244,146	1,296,181			1,244,146	1,296,181
1941	1,010,039	1,121,513			1,010,039	1,121,513
1942	951,243	1,051,432			951,243	1,051,432
1943	2,744,930	3,041,609			2,744,930	3,041,609
1944	1,204,303	1,321,274			1,204,303	1,321,274
1945	220,526	232,070			220,526	232,070
1946	886,578	976,190			886,578	976,190
1947	2,260,506	2,756,888			2,260,506	2,756,888
1948	541,439	786,850	50,697	$60,902	592,136	847,752
1949	382,344	577,810	107,655	141,948	489,999	719,758
1950	582,562	854,236	142,296	201,710	724,858	1,055,946
1951	667,425	1,036,414	184,681	283,914	852,107	1,320,328
1952	471,077	858,092	320,131	504,817	791,208	1,362,909

Source: U. S. Department of Commerce.

Imports tend to be variable from year to year because substantial stocks are held in the United States and are replenished from time to time. In recent years the United States has obtained roughly one-half of its supplies from foreign sources. Present sources can easily supply all United States requirements.

If in time of war only the Western Hemisphere were accessible, our essential requirements could be satisfied from Chilean and domestic sources. Reserves in Chile are large but it must be borne in mind the commodity is a byproduct of nitrate production and therefore the production of iodine depends upon the continued production of nitrate.

If for some reason Chile were no longer accessible as a supplier, it is believed that it would be possible to increase domestic production sufficiently to provide for the strategically essential requirements. No estimates of iodine reserves in the United States are available but they apparently are adequate for many years of production at present or at any accelerated rate that is anticipated as necessary in a time of emergency.

There appears to be sufficient flexibility in the iodine supply potential to permit adjustment to almost any emergency situation. This is particularly true if an adequate stockpile is maintained as insurance against the possible shortages that might result from cutting off of foreign sources and damage to production facilities.

Senator MALONE. It is your opinion that the Western Hemisphere can be self-sufficient in case of an emergency?

Mr. JOSEPHSON. Yes. If the Chilean production is maintained, there is no question about that.

Senator MALONE. Thank you. Go right ahead.

CRYOLITE

Mr. JOSEPHSON. Cryolite. Cryolite is a sodium-aluminum-fluoride principally used as as an electrolyte in the production of aluminum. The only known commercial deposit of natural cryolite is in Greenland.

About 38,000 tons of cryolite were imported into the United States in 1952.

Estimates of reserves in the Greenland deposite have ranged from about 10 years at the present rate of production up to about 25 years.

The aluminum industry prefers natural cryolitee for use in electrolytic cells, particularly when they are being started up. Synthetic cryolite, a manufactured product made from fluorspar, soda ash, and bauxite, is widely used as a substitute but it fumes and sputters more than natural cryolite on the startup.

The Western Hemisphere can be considered to be self-sufficient as it contains the only known cryolite mine. If supplies from this source were cut off from the United States in wartime synthetic cryolite would be substituted.

Senator MALONE. And could be used satisfactorily in an emergency?

Mr. JOSEPHSON. It could be used.

Senator MALONE. The text of natural cryolite will be placed in the record at this point as a part of your testimony, Mr. Josephson.

(The information is as follows:)

CRYOLITE (NATURAL)

Cryolite is a sodium-aluminum-fluoride used as an electrolyte in the production of aluminum, as a binder in abrasives, and in insecticides and ceramics. The only known commercial deposit of natural cryolite is in Greenland. Roughly half the output is shipped to one processor in the United States and most of the remainder to a processor in Denmark, with smaller shipments occasionally to Canada.

The following table shows cryolite imported into the United States, 1940–52:

Cryolite[1] imported into the United States, 1940–52[2]

	Short tons		Short tons
1940	28,961	1947	22,008
1941	29,886	1948	2,353
1942	72,313	1949	20,506
1943	51,968	1950	17,134
1944	17,562	1951	38,851
1945	20,106	1952	38,373
1946	11,424		

[1] Natural and synthetic cryolite not separately classified.
[2] U. S. Department of Commerce.

The following table shows refined cryolite exported from the United States:

Cryolite[1] exported from the United States, 1940–52[2]

	Short tons		Short tons
1940	(3)	1947	936
1941	(3)	1948	713
1942	424	1949	363
1943	2,990	1950	2,072
1944	1,064	1951	1,597
1945	1,901	1952	83
1946	1,299		

[1] Natural and synthetic cryolite not separately classified.
[2] U. S. Department of Commerce.
[3] Not available.

About 1.4 tons of crude cryolite must be processed to recover 1 ton of refined cryolite suitable for use by the aluminum industry.

Estimates of reserves in the Greenland deposit have ranged from about 10 years at the present rate of production up to about 25 years.

The aluminum industry prefers natural cryolite for use in electrolytic cells, particularly when they are being started up. Synthetic cryolite, a manufactured product made from fluorspar, soda ash, and bauxite, is widely used as a substitute, but it fumes and sputters more than natural cryolite on the startup.

The Western Hemisphere can be considered to be self-sufficient as it contains the only known cryolite mine. If supplies from this source were cut off from the United States in wartime synthetic cryolite would be substituted.

Senator MALONE. In each case it will be understood that you will at a later date send us supplementary information to add to your statement of today.

Mr. JOSEPHSON. As needed.

CORUNDUM

Corundum is a natural oxide of aluminum. It is the second hardest natural mineral known, and is used as an abrasive material either in grain form or bonded into grinding wheels. Its principal applications are in optical glass grinding and in specialized grinding wheels for such uses as rough grinding of castings. Approximately three-fourths of the corundum grain is used by the optical industry, and the remainder is sold in coarser sizes to manufacturers of grinding wheels. The commodity is currently classified as strategic because of its use in lens grinding.

Corundum has been produced in the Western Hemisphere from time to time in the past, but now virtually all of the United States supply is obtained from South Africa. The mineral is imported and processed by a single firm, the American Abrasive Co. of Westfield, Mass. This company maintains a purchasing organization in South Africa, which collects corundum from the producers and ships it to the United States.

Although corundum occurrences are known in many countries, world production is relatively small. In 1951 the Union of South Africa, our principal source, produced about 5,000 short tons. United States imports in that year totaled 4,893 short tons.

Since World War II nearly all of the available supplies have been needed for current consumption.

Fortunately a large measure of relief from corundum supply problems is found in the fact that fused alumina is used widely as a substitute. It is noteworthy that during periods when corundum imports have been low no atmosphere of acute emergency has developed in the industry. The competition between the two materials more or less limits the price that can be paid for corundum. In grain form the two materials usually sell at approximately the same price.

On the other hand, corundum is still considered by some consumers to be the more efficient abrasive, and therefore preferable. Estimates of the loss of efficiency that would result from the substitution of fused alumina for corundum in some operations have ranged up to 30 percent. Additional research is needed to more accurately determine the actual differentials.

If in time of war supplies from Africa were cut off, some corundum production capacity probably could be developed in the Western Hemisphere, as deposits have been reported at various locations in that area. Canada at one time was a substantial producer, and three belts of corundum-bearing deposits are known in Ontario. These reserves are considered to be low grade, and therefore the product would be high cost—probably far in excess of the price of African. During World War II efforts to develop corundum production in the United States met with little success, and there is no reason to believe that future efforts will be any more successful.

The most promising means of achieving self-sufficiency in the Western Hemisphere appears to be the further use of substitutes. A high degree of substitution is known to be practical and further investigation may prove fused alumina or other substitutes to be completely adequate for all corundum applications.

Senator MALONE. That is very interesting. Great progress has been made in recent years in the production of material to displace corundum.

Mr. JOSEPHSON. Yes, fused alumina has fairly well displaced it.

Senator MALONE. The text will appear in the record at this point as a part of Mr. Josephson's testimony at this point in the record.

(The information is as follows:)

CORUNDUM

Corundum, an oxide of aluminum, is the second hardest natural mineral known.

Corundum is used as an abrasive material either in grain form or bonded into grinding wheels. Its principal applications are in optical glass grinding and in specialized grinding wheels for such uses as rough grinding of castings. Approximately three-fourths of the corundum grain is used by the optical industry, and the remainder is sold in coarser sizes to manufacturers of grinding wheels. The commodity is currently classified as strategic because of its use in lens grinding.

Corundum has been produced in the Western Hemisphere from time to time in the past, but now virtually all of the United States supply is obtained from South Africa. The mineral is imported and processed by a single firm, the American Abrasive Co. of Westfield, Mass. This company maintains a purchasing organization in South Africa, which collects corundum from the producers and ships it to the United States.

Although corundum occurrences are known in many countries, world production is relatively small, probably under 10,000 tons per year.

The following tables contain production, foreign trade, and consumption statistics of this commodity.

Corundum production, imports, and consumption

Year	Crude corundum concentrate [1]		Corundum grain used in the United States		
	World production outside Soviet bloc	Imports into United States	Grinding wheels	Optical	Total
	Metric tons	*Short tons*	*Short tons*	*Short tons*	*Short tons*
1944	6,500	6,402	1,032	3,763	4,795
1945	7,000	6,244	929	3,003	3,932
1946	3,000	4,207	880	1,890	2,770
1947	2,500	2,401	622	2,371	2,993
1948	3,000	3,612	701	1,175	1,876
1949	4,000	2,013	264	1,320	1,584
1950	4,000	3,543	412	1,626	2,038
1951	5,000	4,893	1,080	2,750	3,830
Total	37,000	33,315	5,920	17,898	23,818

[1] 4 tons of crude corundum concentrate is usually required to make 3 tons of commercial corundum grain

Production of corundum by principal countries in metric tons, 1945–51

Country [1]	1945	1946	1947	1948	1949	1950	1951
India	409	97	182	284	1,493	304	(2)
Madagascar	50	21	1	4	7		
Nyasaland	328	379			113	187	101
Union of South Africa	4,379	1,854	2,313	2,537	2,464	3,201	4,563

[1] In addition to the countries listed, corundum is produced in U. S. S. R.: but data on production are not available.

[2] Data not available.

Since World War II nearly all of the available supplies have been needed for current consumption.

Fortunately a large measure of relief from corundum-supply problems is found in the fact that fused alumina is widely used as a substitute. It is noteworthy that during periods when corundum imports have been low no atmosphere of acute emergency has developed in the industry. The competition between the

two materials more or less limits the price that can be paid for corundum. In grain form the two materials usually sell at approximately the same price.

On the other hand, corundum is still considered by some consumers to be the more efficient abrasive and, therefore, preferable. Estimates of the loss of efficiency that would result from the substitution of fused alumina for corundum in some operations have ranged up to 30 percent. Additional research is needed to more accurately determine the actual differentials.

If in time of war supplies from Africa are cut off, some corundum production capacity probably could be developed in the Western Hemisphere, as deposits have been reported at various locations in that area. Canada at one time was a substantial producer, and three belts of corundum-bearing deposits are known in Ontario. These reserves are considered to be low grade, and therefore the product would be high cost—probably far in excess of the price of African. During World War II efforts to develop corundum production in the United States met with little success and there is no reason to believe that future efforts will be any more successful.

The most promising means of achieving self-sufficiency in the Western Hemisphere appears to be the further use of substitutes. A high degree of substitution is known to be practical and further investigation may prove fused alumina or other substitutes to be completely adequate for all corundum applications.

CELESTITE

Mr. JOSEPHSON. The next item is celestite or strontium sulfate. It is the principal commercial strontium mineral. The bulk of the celestite consumed is converted into various strontium compounds. Strontium burns with a characteristic red color. This property is utilized in such applications as tracer bullets, flares, rockets, and fusees.

Domestic deposits occur in several States, including California, Texas, and Washington. However, nearly all of the strontium minerals currently being consumed in the United States are imported from the United Kingdom and Mexico. The market is small. Imports commonly range from about 9,000 to 14,000 tons. Most of the processing facilities are in the East, and high-grade celestite can be secured more cheaply from foreign sources than from the best domestic sources.

Although domestic deposits have not been explored thoroughly, the measured, indicated, and inferred ore in known deposits may total as much as 3.5 million tons, virtually all of which under present conditions is considered to be marginal or submarginal. No estimate of reserves in Mexico is available, but they apparently are substantial and high grade.

Recent domestic production has been very small and sporadic—generally not more than a few hundred tons annually. The Bureau of Mines has done some research on a flotation process for recovering celestite from the large deposits in Texas. During World War II a domestic firm processed Texas ore, but the market was found to be too small and costs too high for economical operation, so production was discontinued.

Senator MALONE. When you say too high cost for an operation you are referring, of course, to competition with the imported material?

Mr. JOSEPHSON. Yes.

Senator MALONE. There has been no attempt in any manner to further the domestic industry by any protection whatsoever?

Mr. JOSEPHSON. That is right.

Senator MALONE. It might be in the same situation as Dr. Coulter referred to several times yesterday in his testimony. In some cases, in order to have an industry, it is necessary that the protection must come first.

Mr. JOSEPHSON. There is some justification for that viewpoint. As a matter of fact, this next paragraph points out that the principal problem facing the potential domestic producer is competition from foreign sources.

Senator MALONE. Go right ahead.

Mr. JOSEPHSON. With a small market and transportation-cost disadvantage, domestic producers have found peacetime competition difficult.

If European sources were cut off in wartime, it is believed that the stockpile can satisfy United States requirements until production facilities can be built to provide adequate supplies from domestic deposits and Mexico.

Senator MALONE. That is very interesting. Then it would be just a question of whether Congress considered the industry important enough to compensate for the difference in costs.

Mr. JOSEPHSON. That is right. The difference in cost and the difficulties of establishing a production facility during wartime. It is just simply a matter of choice.

Senator MALONE. There is practically no difficulty, however, except economic.

Mr. JOSEPHSON. Yes.

Senator MALONE. The text on celestite will be accepted and appear in the record at this point as a part of Mr. Josephson's testimony.

(The information is as follows:)

CELESTITE

Celestite is a mineral consisting essentially of strontium sulfate. Strontianite (strontium carbonate) is much less plentiful and consequently celestite is the principal commercial strontium mineral. The bulk of the celestite consumed is converted to various strontium compounds. Strontium burns with a characteristic brilliant red color. This property is utilized in such applications as tracer bullets, which permit the gunner to judge the accuracy of his aim. Distress and warning signal equipment, including flares, rockets, and fusees are used by ships, railroad, and trucks. Other applications of strontium compounds are in ceramics and medicine. Strontium metal and some of its alloys are used as "getters" for extracting the last traces of gases from electronic tubes.

Domestic deposits occur in several States, including California, Texas, Washington, Arkansas, Utah, Tennessee, and others. However, nearly all of the strontium minerals currently being consumed in the United States are imported from the United Kingdom and Mexico. As most of the processing facilities are in the East, high-grade celestite can be secured more cheaply from foreign sources than from the best domestic deposits in the West.

Although domestic deposits have not been explored thoroughly, the measured, indicated, and inferred ore in known deposits may total as much as 3.5 million tons, virtually all of which under present conditions is considered to be marginal or submarginal. No estimate of reserves in Mexico is available, but they apparently are substantial and high grade.

Recent domestic production has been small and sporadic—generally not more than a few hundred tons annually.

The following table shows imports of strontium minerals by countries of origin.

Strontium minerals[1] imported for consumption in the United States, 1947–52, by countries

[In short tons]

Country	1947	1948	1949	1950	1951	1952
Canada			59		38	59
Mexico	3,937	1,114	1,158	1,975	2,034	1,297
Spain	5,836	14,614	3,263			
United Kingdom	4,344	6,943	4,904	6,655	11,972	8,161
Total	14,117	21,771	9,384	8,630	14,044	9,517

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

Source: U. S. Department of Commerce.

The Bureau of Mines has done research on a flotation process for recovering celestite from the large deposits in Texas. During World War II a domestic firm processed Texas ore, but the market was found to be too small and costs too high for economical operation, so production was discontinued. Users of celestite for chemical purposes generally specify a minimum of 92 percent $SrSO_4$, maximum of 4 percent $CaSO_4$, and maximum of 4 percent $BaSO_4$. Imported material usually is about 95–96 percent $SrSO_4$.

The principal problem facing potential domestic producers is competition from foreign sources. With a small market and transportation and other cost disadvantages, domestic producers have found peacetime competition difficult.

If European sources were cut off in wartime, it is believed that the stockpile can satisfy United States requirements until production facilities can be built to provide adequate supplies from domestic deposits and Mexico.

INDUSTRIAL DIAMONDS

Mr. JOSEPHSON. The next item is industrial diamonds. Diamond, the hardest mineral substance, has become an important strategic material because of its use as an abrasive. The demand for industrial diamonds has increased greatly in recent years with the growth in use of cemented carbide cutting tools which are so hard that diamond grinding is required in their sharpening. Diamonds are also used for core drilling, truing grinding wheels, and for wire drawing dies.

Whereas the United States is by far the largest consumer of diamonds, it produces none. In 1952 consumption in the United States totaled about 12 million carats. Our supplies are obtained principally from Africa with small quantities from South America.

Senator MALONE. In general, what is the price range per carat? Of course, there is such a wide price range on account of difference in size and quality.

Mr. JOSEPHSON. It is just under $4, but let me correct that in the record. If I remember correctly, it is $3.79.

Senator MALONE. It is in the neighborhood of $3.75 to $4.

Mr. JOSEPHSON. Yes; but I will verify the figure in the record.

Senator MALONE. Go ahead.

Mr. JOSEPHSON. It is noteworthy that the Western Hemisphere accounts for only about 1 percent of the total world output.

Some 95 percent of the industrial diamond supply is marketed by the producers through an organization called Industrial Distributors, Ltd.

Prior to the period of most rapid growth in the use of industrials, producers and dealers had accumulated a stockpile of over 50 million

carats. However, during World War II, and since then, this stockpile is said to have been reduced to the vanishing point, and in the future the available supply will come almost entirely from current production.

Until recent years the demand has been reasonably well serviced by the producing industry. Some supplies have been channeled into the United States strategic stockpile. However, in the past few years shortages have been experienced in spite of the major production expansion programs that have been undertaken by producers.

In case of an emergency in which the United States would be cut offi from its African diamond supplies, the industries that have come to depend upon diamonds would face very serious problems. The relatively small production in South America might be increased somewhat through an aggressive exploration and development program but the potential of this area is unpredictable on the basis of the meager data at hand. Under these conditions placement of major dependence on South America is not warranted.

There is no current prospect of substantial commercial production in the United States. Fortunately, there are a number of means by which the United States can prepare for a possible wartime diamond shortage. Stockpiling is particularly advantageous, because it provides the material with which consumers are familiar. Increasing the efficiency of grinding practice and recovery of diamond-bearing grinding sludges will conserve available supplies. Research by the Bureau of Mines has shown that proper orientation of diamonds in drilling bits will extend their lives materially—as much as 300 to 400 percent in many instances. Diamond salvage from sludges is receiving greater attention and it is estimated hat almost 1 million carats will be salvaged by industry this year.

Progress is being made in the direction of self-sufficiency through the development of alternate grinding methods, including the electrodischarge processes, electrolytic processes, ultrasonic abrasive grinding, silicon carbide belt grinding and silicon carbide wheel grinding. Research is also being done on hard materials which may serve as diamond substitutes. Information accumulated in research on the crystal structure and synthesis of these hard materials may lead ultimately to the synthesis of diamond itself.

As all of these projects can make important contributions to the eventual solution to this wartime supply problem, they deserve the continued support of both industry and Government.

Senator MALONE. What did you say in the preliminary statement about the consumption of this material annually?

Mr. JOSEPHSON. Around 12 million carats. That was the 1952 figure. It has been rising.

Senator MALONE. About what percentage would be salvaged, in your judgment?

Mr. JOSEPHSON. Would be salvaged?

Senator MALONE. I understood you to say that certain numbers of diamonds will be recovered this year.

Mr. JOSEPHSON. They have never reached a million carats yet, but they hope to reach the order of a million.

Senator MALONE. That would be about 8 to 10 percent.

Mr. JOSEPHSON. Yes.

Senator MALONE. If the emergency occurred within, say, a year or two, what percentage of this 12 million carats could be substituted

by other grinding methods and other methods, say, in drilling, if any such substitute is available?

Mr. JOSEPHSON. Of course, that would depend entirely upon the degree of the emergency. In other words, the amount of diamond on hand, and so forth.

Senator MALONE. Yes. Of course. Just take it for granted that suddenly you just had to get right down to bedrock, what percentage within the next year or two do you think you could displace with other methods.

Mr. JOSEPHSON. The answer to that would depend entirely on how you assumed some of these alternate grinding methods could be developed. I have seen estimates that purported to claim that as much as 25 percent could be substituted or displaced, if you will, within the first year with rising percentages over a period of 3 to 4 years thereafter, as the new methods were developed, as the familiarity of industry increased, and so forth. You could not assume that you could substitute a very high percent in the first year without losing substantially in the way of efficiency of operation.

Senator MALONE. I did understand you to say that there was a possibility of eventual substitution.

Mr. JOSEPHSON. Yes; that is right, by these various means I outlined.

Senator MALONE. And that justifies in your judgment a continuation of the experiments along that line?

Mr. JOSEPHSON. Yes; that is right.

Senator MALONE. There is no difficulty, of course, in transportation of this material. That can be done by airplane or submarine.

Mr. JOSEPHSON. That is right. I was interested in your discussion of that with Mr. Zinner. Diamonds run about 2,200 carats to the pound so we are talking in the order of 2 or 3 tons of diamonds in a year, which, of course, could be put on a few airplanes. Nobody would be foolish enough to put them all on one. You could undoubtedly fly them.

Senator MALONE. Or submarine or any other means of transportation.

Mr. JOSEPHSON. Yes; that is right.

Senator MALONE. That is very interesting. Do you have a text?

Mr. JOSEPHSON. Yes.

Senator MALONE. The text on industrial diamond will be accepted and included at this point in Mr. Josephson's testimony.

(The information is as follows:)

INDUSTRIAL DIAMONDS

Diamond, the hardest mineral substance, has become an important strategic material because of its use as an abrasive. Diamonds are used both as individual stones, and as crushed material. The larger proportion of the latter is bonded into grinding wheels. The demand for industrial diamonds has increased greatly in recent years with the growth in use of cemented carbide cutting tools. These carbides are so hard that diamond grinding is required in the sharpening of tools and forming of other objects made from these materials. Diamonds also are used for core drilling, truing grinding wheels, and for wire drawing dies. Because of its esssentiality in these uses diamond has become a very important factor in

maintaining the high efficiency of American manufacturing methods. An estimate of the distribution of diamond use for 1952 is shown in the following table:

Distribution of industrial diamond use in 1952

	Carats
Crushing boart, and diamond powder or dust	9,000,000
Industrial stones:	
Core and blast hole drilling	1,000,000
Dressing grinding wheels	400,000
Wire dies	50,000
Boring and turning	40,000
Miscellaneous	410,000
Exports	1,100,000
Total	12,000,000

Whereas the United States is the largest consumer of diamonds, it produces none. Our supplies are obtained principally from Africa with small quantities from South America. World production in 1952 is shown in the following table:

World production of diamonds in 1952

[In metric carats]

	Total production	Industrial diamonds	
		Production	Percent of the total
Africa:			
Angola	743,302	304,754	41
Belgian Congo	11,608,763	11,200,000	96
French Equatorial Africa	163,400	147,000	90
French West Africa	136,080	109,000	80
Gold Coast (reported)	2,189,557	1,860,000	85
Sierra Leone	451,426	311,484	69
South West Africa	541,027	108,000	20
Tanganyika	143,023	62,000	43
Union of South Africa:			
"Pipe" mines:			
Premier	1,293,548	1,000,000	77
De Beers group	786,354	393,000	50
Others	13,236	7,000	50
Alluvial mines	[1] 282,681	140,000	50
Other regions:			
Brazil	[2] 200,000	100,000	50
British Guiana	38,305	13,000	33
Venezuela	98,291	33,000	33
Australia, Borneo, India, etc.	[2] 5,000	3,000	60
Total	18,694,000	15,800,000	84½

[1] Including the state-owned mines in Namaqualand.
[2] Estimate, subject to revision.

It is noteworthy that the Western Hemisphere accounts for only about 1 percent of the total world output.

Some 95 percent of the industrial diamond supply is marketed by the producers through an organization called the Industrial Distributors, Ltd. World production and imports to the United States during the past 5 years are shown in the following table:

Year	World production of industrial diamonds	United States imports of industrial diamonds
	Carats	Carats
1948	7,700,000	10,421,207
1949	11,600,000	6,261,687
1950	12,600,000	10,835,596
1951	14,000,000	12,049,722
1952	15,800,000	13,672,093

Prior to the period of most rapid growth in use of industrials, producers and dealers had accumulated a stockpile of over 50 million carats. However, during World War II and since then this stockpile is said to have been reduced to the vanishing point and in the future the available supply will come almost entirely from current production.

Until recent years the demand has been reasonably well serviced by the producing industry and some supplies have been channeled into the United States strategic stockpile. However, in the past few years shortages have been experienced in spite of the major production expansion programs that have been undertaken by producers.

In case of an emergency in which the United States would be cut off from its African diamond supplies, the industries that have come to depend upon diamonds would face very serious problems. The relatively small production in South America might be increased somewhat through an aggressive exploration and development program but the potential of this area is unpredictable on the basis of the meager data at hand. Under these conditions placement of major dependence on South America is not warranted.

There is no current prospect of substantial commercial production in the United States. Fortunately, there are a number of means by which the United States can prepare for a possible wartime diamond shortage. Stockpiling is particularly advantageous because it provides the material with which consumers are familiar. Increasing the efficiency of grinding practice and recovery of diamond-bearing grinding sludges will conserve available supplies. Research by the Bureau of Mines has shown that proper orientation of diamonds in drilling bits will extend their lives materially—from 300 to 400 percent. Diamond salvage from sludges is receiving greater attention and it is estimated that almost 1 million carats will be salvaged by industry this year.

Progress is being made in the direction of self-sufficiency through the development of alternate grinding methods, including the electro-discharge processes, electrolytic processes, ultrasonic abrasive grinding, silicon carbide belt grinding, and silicon carbide wheel grinding. Research is also being done on hard materials which may serve as diamond substitutes. Information accumulated in research on the crystal structure and synthesis of these hard materials may lead ultimately to the synthesis of diamond itself.

As all of these projects can make important contributions to the eventual solution to this wartime supply problem, they deserve the continued support of both industry and Government.

Senator MALONE. Proceed.

FLUORSPAR

Mr. JOSEPHSON. The next commodity is fluorspar. Fluorspar has a number of essential uses. At present the largest single use is in steelmaking where it acts as a flux. The second largest use is as a raw material in the manufacture of hydrofluoric acid.

The United States is the largest consumer of fluorspar in the world. In 1952 it used a total of 521,000 tons, but domestic production capacity supplies only about two-thirds of the tonnage consumed. Mexico is the largest supplier of foreign fluorspar to the United States. Germany, Spain, Canada, and Italy also supply the United States with substantial quantities.

In the past few years there has been a shortage of fluorspar, but supplies have now increased sufficiently to satisfy current requirements.

In event of an emergency that would cut off sources outside the Western Hemisphere it seems probable that the stockpile and increased production in the United States, Mexico, and Canada could meet the essential defense requirements. Facilities now in being in the United States could not supply all of the anticipated demand.

Fluorspar reserves containing 35 percent or more calcium fluoride would include nearly all the known deposits that are workable under

present economic and technologic conditions. Reserves of domestic ore containing 35 percent or more calcium fluoride are estimated by the United States Geological Survey to total 15 million short tons. If reserves in Mexico and Canada are added to those of the United States the total of ore containing over 35 percent is estimated to be 23 million short tons. An additional 500,000 short tons are estimated for other known Western Hemisphere deposits. United States reserves of material containing 15 to 35 percent calcium fluoride are estimated to be 20 million short tons.

No satisfactory substitute has been found for fluorspar in the manufacture of steel. More research on this problem is needed. Similarly, hydrofluoric acid is essential in most of its uses, and therefore the opportunity for substitution is limited.

A large potential source of fluorine exists in the fertilizer industry because fluorine is a constituent of phosphate rock. Recovery of this fluorine is practiced to a limited extent but wider exploitation of this resource could reduce the need for fluorspar.

Although the United States is no longer self-sufficient in fluorspar the proximity of the supplementary sources in Canada and Mexico minimizes the risk of supply interdiction in wartime. There are a number of avenues through which the self-sufficiency position of the United States may be improved. United States fluorspar reserves probably can be increased through exploration and research on beneficiation. Development of a satisfactory flux to serve as a substitute for metallurgical grade fluorspar would reduce the fluorspar requirement. Research and development projects directed toward the recovery and utilization of waste fluorine from phosphate-rock processing can increase substantially the domestic production of fluorine-bearing raw materials.

Senator MALONE. Is any particular work being conducted at this time to increase the recovery of fluorine from phosphate rock?

Mr. JOSEPHSON. Yes. The industry has done quite a little. TVA has done some. The Bureau of Mines has a project in one of its laboratories. The material that is recovered in industry now is principally the silicate form which is useful for some applications, such as water fluorination and so forth, but it does not have the form that is most valuable in industry. TVA has developed one means of producing a calcium fluoride, which of course is the desirable form because it is a direct substitute for fluorspar. It, however, has some very serious technical flaws and therefore it is not an accepted commercial process as yet. There is progress that is being made and we want to urge that research be continued because we feel it is a marvelous opportunity.

Senator MALONE. Do you have a complete text?

Mr. JOSEPHSON. Yes.

Senator MALONE. In your text the amount of fluorspar used and its cost is outlined?

Mr. JOSEPHSON. The statistical background is in there.

Senator MALONE. So the text on fluorspar will be accepted and appear in the record at this time, as a part of Mr. Josephson's testimony.

(The information is as follows:)

FLUORSPAR

The term "fluorspar" commonly is applied to the mineral fluorite, calcium fluoride. It occurs widespread throughout the world in veins and beds or as dis-

seminated deposits. It often is intimately mixed with barite, galena, sphalerite, and other minerals.

In general there are three grades of fluorspar—acid, metallurgical, and ceramic. Acid grade usually is specified as a material containing a minimum of 97 percent CaF_2. Metallurgical grade usually contains less than 97 percent CaF_2 with a minimum of about 60 percent effective CaF_2 (effective CaF_2 is calculated by subtracting 2½ percentage units of CaF_2 for each percentage unit of SiO_2 present). Lump material is desired for metallurgical use, however, a small tonnage of nodulized flotation concentrates is consumed. Ceramic grade is not standardized.

Fluorspar has a number of essential uses. At present the largest single use is in steelmaking, where it acts as a flux. The second largest use is as a raw material in the manufacture of hydrofluoric acid, which in turn is used in the production of gasoline, refrigerants, synthetic cryolite and aluminum fluoride, and in processing uranium. The following table shows consumption of fluorspar, by uses, in 1948–52.

Fluorspar (domestic and foreign) consumed in the United States, 1940–52

[In short tons]

Year	Steel	Hydrofluoric acid	Glass	Enamel	Iron foundry and ferroalloys	All other	Total
1940	155,500	37,000	13,400	5,500	4,600	2,500	218,500
1941	210,400	56,000	20,300	7,300	5,100	4,500	303,600
1942	242,600	81,600	18,500	3,100	7,800	7,200	360,800
1943	234,148	113,614	20,592	1,726	7,260	11,545	388,885
1944	230,201	129,553	27,315	2,547	7,815	12,739	410,170
1945	197,916	109,315	31,874	3,695	6,786	6,504	356,090
1946	160,735	83,901	39,852	6,739	6,969	4,994	303,190
1947	209,395	100,363	42,130	8,938	6,567	8,745	376,138
1948	232,687	107,280	37,247	8,871	8,817	11,367	406,269
1949	201,501	89,152	30,797	5,510	7,816	10,445	345,221
1950	240,802	124,440	33,440	7,723	9,709	10,007	426,121
1951	276,654	151,698	35,505	6,736	9,348	17,071	497,012
1952	271,759	178,265	34,460	5,142	(1)	31,874	521,500

[1] Included with "All Other."

Fluorspar is produced in many countries throughout the world. The major producing countries in the Western Hemisphere are Canada (principally Newfoundland), Mexico, and the United States. The following tables show shipments of fluorspar from domestic mines and imports into the United States from 1940 to 1952:

Fluorspar (all grades) shipped from mines in the United States, 1940–52

	Short tons		Short tons
1940	233,600	1947	329,484
1941	320,669	1948	331,749
1942	360,316	1949	236,704
1943	406,016	1950	301,510
1944	413,781	1951	347,024
1945	323,961	1952	333,769
1946	277,940		

General imports of fluorspar into the United States, by countries

Year	Canada (including Newfoundland)	Mexico	France	Germany	Spain	Italy	Algeria	Union of South Africa	Tunisia	French Morocco	United Kingdom	Total
	Containing more than 97 percent calcium fluoride											
1940	1,344	1,555	151									3,050
1941		1,516										1,516
1942		1,882										1,882
1943		1,854										1,854
1944	2,352	2,779										5,131
1945	7,683	5,480			2,272							15,435
1946	2,688	3,932										6,620
1947	8,256	7,089			276							15,621
1948	14,280	5,916										20,196
1949	15,344	2,907				2,239						20,490
1950	12,163	5,306	560	8,495	9,653	7,311						43,488
1951	15,289	3,819	849	14,327	11,583	6,492	560	72				52,991
1952	13,902	22,222	784	28,210	24,621	18,088						107,827
	Containing not more than 97 percent calcium fluoride											
1940	2,296		5,584		112				829			8,821
1941		2,936			3,070						2	6,008
1942	[1]	269										269
1943	7,144	18,661			15,540			570				41,915
1944	13,790	60,843			9,177			3,557			1	87,368
1945	3,649	56,591			25,051							85,291
1946	310	19,767			2,791							22,868
1947	2,334	44,528			11,766	4,126						62,754
1948	2,100		73,492	1,375	9,718	4,745						91,430
1949		55,331	1,532		12,648	5,618						75,129
1950	2,000	67,745	2,212	21,129	25,649	2,411						121,146
1951	6,171	60,206	566	34,747	21,282	5,312						128,284
1952	4,895	159,846		32,318	35,098	12,354		2,557	2,258	2,249		251,575

[1] Less than 1 ton.

The United States is the largest consumer of fluorspar in the world, but current domestic production supplies only about two-thirds of the tonnage consumed. Mexico is the largest supplier of foreign fluorspar to the United States. Germany, Spain, Canada, and Italy also supply the United States with substantial quantities.

In the past few years there has been a shortage of fluorspar but supplies have now increased sufficiently to satisfy current requirements.

In event of an emergency that would cut off sources outside the Western Hemisphere it seems probable that the stockpile and increased production in the United States, Mexico, and Canada could meet the essential defense requirements. Discoveries of additional fluorspar in Mexico during recent years and expansion of production facilitites in both Mexico and Newfoundland have contributed to the production potential. Facilities now in being in the United States could not supply all of the anticipated demand.

Fluorspar reserves containing 35 percent or more calcium fluoride would include nearly all the known deposits that are workable under present economic and technologic conditions as well as some deposits that cannot now be mined economically because they are remote from markets, are subject to unusually high mining and milling costs, or contain excessive amounts of undesirable impurities. A few deposits omitted from this group because they contain less than 35 percent calcium fluoride may be minable because they are near markets

and can be mined and processed easily. Measured, indicated, and inferred reserves of domestic ore containing 35 percent or more calcium fluoride are estimated by the United States Geological Survey to total 15 million short tons averaging about 45 percent calcium fluoride. If reserves in Mexico and Canada are added to those of the United States, the total of ore containing over 35 percent is estimated to be 23 million short tons. An additional 500,000 short tons are estimated for other known Western Hemisphere deposits. United States reserves of material containing 15 to 35 percent calcium fluoride are estimated to be 20 million short tons with an average calcium fluoride content of about 20 percent.

No satisfactory substitute has been found for fluorspar in the manufacture of steel. More research on this problem is needed. Similarly, hydrofluoric acid is essential in most of its uses, and therefore the opportunity for substitution is limited.

A large potential source of fluorine exists in the fertilizer industry because fluorine is a constituent of phosphate rock. Recovery of this fluorine is practiced to a limited extent but wider exploitation of this resource could reduce the need for fluorspar.

Although the United States is no longer self-sufficient in fluorspar the proximity of the supplementary sources in Canada and Mexico minimizes the risk of supply interdiction in wartime. There are a number of avenues through which the self-sufficiency position of the United States may be improved. United States fluorspar reserves probably can be increased through exploration and research on beneficiation. Development of a satisfactory flux to serve as a substitute for metallurgical grade fluorspar would reduce the fluorspar requirement. Research and development projects directed toward the recovery and utilization of waste fluorine from phosphate rock processing can increase substantially the domestic production of fluorine-bearing raw materials.

ASBESTOS

Asbestos is a name applied to a number of fibrous minerals. The principal variety is chrysotile, which is a hydrous magnesium-silicate. There are a number of other varieties, but only two of them, amosite and crocidolite, have substantial commercial markets. Amosite is a complex iron magnesium hydrous silicate and crocidolite a sodium iron hydrous silicate. Certain grades of these three varieties are classified as strategic because they have important defense uses and are obtained from overseas. As the problems involved are quite individual, the three varieties will be discussed separately.

Basic statistics are shown in the following tables:

Asbestos-chrysotile—Imports by country of origin 1948–52

[In short tons]

Year	Canada	Southern Rhodesia	U. S. S. R.	Other [1]	Total
1948	602,216	10,513	15,514	708	628,951
1949	470,783	13,722	1,221	602	486,328
1950	678,358	9,892	426	1,547	690,223
1951	726,770	7,725	2,237	912	737,644
1952	668,860	10,543	1,761	628	681,792

[1] Estimated in part.

Asbestos—Domestic consumption, 1948–52

	Short tons
1948	675,746
1949	532,708
1950	727,002
1951	796,992
1952	[1] 705,000

[1] Estimated.

Asbestos-chrysotile—Domestic production (sales), 1948–52

	Short tons
1948	37,092
1949	43,387
1950	42,434
1951	51,645
1952	[1] 52,000

[1] Estimated.

Asbestos-amosite[1] and crocidolite—Imports by country of origin 1948–52

[In short tons]

Year	Amosite, Union of South Africa	Crocidolite	
		Africa [2]	Bolivia
1948	12,551	3,992	68
1949	14,892	5,191	69
1950	8,105	4,952	104
1951	15,131	5,752	324
1952	[3] 19,300	7,159	413

[1] Union of South Africa is the only source.
[2] Includes small quantities from Australia during certain years.
[3] Estimated.

AMOSITE

Amosite is produced commercially only in South Africa and the United States imported about 19,000 tons in 1952. Amosite is important from the defense standpoint because it is used in making heat insulation products such as coverings for marine boilers and turbines and similar applications. Substantial tonnages also are used as a constituent of 85 percent magnesia, which is a leading industrial insulating material. The past few years have been characterized by shortages of amosite. However, production capacity is being increased considerably in Africa so more adequate servicing of the market may be forthcoming.

As there are no known commercial deposits of amosite in the Western Hemisphere, interruption of the flow of supplies from Africa soon would be felt by the consuming industries in the United States. Accumulation of a stockpile of amosite would, of course, be very desirable to meet such a contingency.

Greater self-sufficiency can be sought principally through the development of substitutes. In periods of shortage some relief can be achieved through substitution of Canadian chrysotile for amosite. Another promising substitute is glass fiber on which considerable research has been done. A glass-fiber substitute for amosite felt insulation has been found to be technically acceptable, but its cost is about seven times as high as the amosite product, and therefore it is not considered to be a practical substitute to date.

Although some progress is being made toward the reduction of United States dependence upon South African amosite in time of emergency no panacea is in sight and therefore stockpiling of amosite still is desirable from the standpoints of cost, quality, and adequate servicing of established users.

CROCIDOLITE

Crocidolite, or blue asbestos, is produced in Australia, Bolivia, and South Africa. The United States purchased about 7,000 tons of African crocidolite in 1952, and about 400 tons of Bolivian.

The African crocidolite is used principally in making asbestos-cement pipe, whereas the Bolivian is primarily valuable for the manufacture of gas filters. The commodity has been classified as strategic because of the latter use. The African crocidolite is not considered strategic.

In a period of emergency, the Western Hemisphere would be self-sufficient in the strategic grade of crocidolite. If South America were cut off in a period of emergency no sources of crocidolite of this quality would be available to the United States. No deposits are known to exist in North America.

A solution to this problem is in sight. It is now anticipated that United States dependence upon foreign crocidolite for strategic filter applications will be eliminated through the substitution of glass fiber.

CHRYSOTILE

Chrysotile is the principal variety of asbestos. In recent years the United States has consumed in excess of 700,000 tons of this type of asbestos annually. Of this total, the bulk is used in making various building and industrial products such as asbestos-cement products, asphalt tile, and asbestos paper, and nearly 30,000 tons of the longer grades of chrysotile is used in the spinning of asbestos fabrics and for other applications in which long fibers are necessary.

A portion of these spinning fibers is used in applications where a very low iron content is necessary, primarily for the insulation of electric cables. As this grade is used in military applications it has been classified as a strategic material.

Only relatively small quantities of chrysotile are produced in the United States (approximately 6 to 8 percent of requirements). The bulk of United States chrysotile supply comes from Canada.

In the past Southern Rhodesia has supplied nearly all of the low-iron fiber used in this country. The only domestic sources of low-iron fiber are a number of mines in Arizona, which produce high-quality fiber, but in very small quantities.

Self-sufficiency may be achieved ultimately through discovery of deposits, development of substitutes and synthesis. Exploration of all of these avenues is being carried on both by industry and Government organizations and these are long-term programs that deserve full and continuing support.

Senator MALONE. In your judgment, then, Mr. Josephson, the outlook is very favorable for ultimate self-sufficiency in the United States?

Mr. JOSEPHSON. Ultimately, yes. We have a lot of work to do yet.

Senator MALONE. The projects you are conducting are discussed in the text?

Mr. JOSEPHSON. Yes, or if it is found that Mr. Holderer feels a little more expansion on that should be included, we can very easily do that.

Senator MALONE. I think it should be included in each case. I am going to suggest that if you will, within the next 2 or 3 weeks, expand your statement on each of the materials that we are not now self-sufficient in the United States or the Western Hemisphere, to include some detail of the experiments, exploration that is being conducted, and the reasons for their continuance, describing the process and annual cost. I think that is very important.

Naturally, in peacetime with the normal trade between nations uninterrupted, obtaining the asbestos is no problem.

Mr. JOSEPHSON. It is a problem in some instances. In other words, it is a selective thing. Certain qualities and certain grades have been very short. There was a period of a year or two in which almost all grades were in short supply.

Senator MALONE. Demand takes care of that.

Mr. JOSEPHSON. Over a period of time.

Senator MALONE. When the demand is sufficient and the price includes a profit, the material is available.

Mr. JOSEPHSON. In asbestos that is certainly true.

Senator MALONE. I think it is true in practically all materials. But when we are talking about our own economic structure, and our own national defense, that presents an additional problem and it is just a question of how serious we consider the problem and how far Congress wants to go in establishing the principle of self-sufficiency in time of emergency.

Mr. JOSEPHSON. We feel it is well worth the continuation and expansion of work on synthesis of the asbestos. It is a difficult technical

problem, and it will take a number of years. But even at this early stage of our laboratory work, we find we can make crystals which will fiberize. Most of the ones we have made so far are too brittle to be of commercial interest. Knowledge of crystalization techniques and of compositions will accumulate over a period of time, and ultimately will result in better quality.

Senator MALONE. Three or five years of work might mark great progress?

Mr. JOSEPHSON. I would suggest that 5 years should be the minimum target.

Senator MALONE. In your judgment if such an objective was established, is there reasonable expectancy that we might become self-sufficient in the Western Hemisphere.

Mr. JOSEPHSON. Of course, that depends primarily upon the capacity, success, and luck of the various research programs. Naturally we would not be supporting such research programs if we did not think there was a good chance of success. Even though the following example may have to be discounted a little as prematurely optimistic, there is an indication of future prospects in the fact that the latest fibrous material that our laboratory has synthesized has sufficiently good properties to warrant asking some asbestos consumers to look it over and see what they think of it. That does not mean our technologists feel it is the ultimate answer, but at least it shows that this research is coming along in a satisfactory manner.

Senator MALONE. With a reasonable stockpile and continuation of your work you feel that the security of the United States would be very well taken care of?

Mr. JOSEPHSON. Yes, ours and other research work. I do not think we can discount the stockpile yet. That is, in the amosite phase. We may soon be able to discount it in the other two.

Senator MALONE. Which will cut down the tonnage of material.

Mr. JOSEPHSON. Yes.

Senator MALONE. I would suggest again, Mr. Josephson that you proceed to describe in more detail the experiments and the important investigations now underway in these materials you have covered in your testimony.

Mr. JOSEPHSON. I will submit that over the period of the next 2 or 3 weeks.

Senator MALONE. We thank you very much for your appearance here.

Mr. JOSEPHSON. Thank you, sir.

(The information requested is as follows:)

ADDITIONAL INFORMATION ON CORUNDUM, CELESTITE, INDUSTRIAL DIAMONDS, FLUORSPAR, AND ASBESTOS

CORUNDUM

The substitution of fused aluminum oxide for corundum was studied by the Munitions Board in connection with stockpiling. A canvass of industry opinion led to the conclusion that stockpiling for grinding wheel applications was no longer necessary. Further study of corundum substitutes may lead to further reduction of dependence on overseas sources of natural corundum.

CELESTITE

Research conducted by the Bureau of Mines on celestite beneficiation, published in Report of Investigations No. 4018, indicated that a concentrate of good quality

can be produced. Commercial firms have also investigated the possible domestic production of celestite and at least one has stated that a satisfactory product could be produced when there is a substantial demand at a sufficiently high price.

INDUSTRIAL DIAMONDS

The progress made during the past few years in the development of the alternate grinding methods is particularly noteworthy because they offer a large measure of relief from a major diamond shortage. The electro-discharge processes include those that remove stock by sparks or an arc maintained between the work (the anode) and the cathode. Electrolytic grinding is accomplished by passage of current between the work and cathode through an electrolyte. In ultrasonic grinding the tool is vibrated at ultrasonic frequencies as an abrasive, such as boron carbide, in a liquid flows over the tool and the work. Silicon carbide belt and wheel grinding are not new but they are receiving renewed attention because of their potential utility in grinding of carbides.

All of these methods are undergoing experimental testing on a substantial scale in industry and some are in full production installations. The industry anticipates the gradual adoption of these processes over a period of time but the rate and ultimate degree of their substitution for diamond grinding is presently unpredictable.

Research on hard materials that may serve as diamond substitutes also is progressing but is still in a relatively early stage. Some of the materials, such as boron carbide, are available commercially and have a limited use, but there is a need for new or improved materials that have greater utility as diamond substitutes. The Bureau of Mines maintains a research project to contribute to progress in this field. To date the Bureau has worked on methods of making various hard materials and better compacts. Currently primary attention is being given to the production and testing of hafnium carbide. To date a major weakness of the prospective substitutes is a tendency toward brittleness. Information is being accumulated on the crystal structure and synthesis of the hard materials and the findings are being published in a series of reports.

FLUORSPAR

Fluorspar deposits in the United States are being explored by both industry and Government agencies and in both Mexico and Canada new resources are being developed. These are all contributing to an improvement in the fluorspar self-sufficiency position of North America. A small amount of research is also being done on recovery of fluorspar from complex ores. Even more noteworthy from the long-term viewpoint is the growing interest in recovery of fluorine-containing byproducts from the processing of phosphate rock. A considerable number of phosphate processing plants have equipment to recover fluorine compounds. These are marketed for use in water treatment, insecticides, and other applications but the market is relatively limited at present. Growth in water fluoridation may increase the market considerably. Some development work has also been done on recovering the fluorine in calcium fluoride form which could be directly substituted for natural fluorspar, but this has not reached commercial success. The problem is being studied by both industry and Government organizations. There is a need for improvement of equipment to increase recovery, development of methods and equipment for producing high-grade calcium fluoride and hydrofluoric acid economically.

The Bureau of Mines is contributing to the solution of fluorspar supply problems through research on fluorine from phosphate rock, research on beneficiation of complex ores, and occasional investigation of deposits. As the funds available are very limited, these are all relatively small-scale projects.

ASBESTOS

Investigation of substitutes for products containing amosite asbestos is being conducted by the Navy Department. The development of substitutes is encouraged by using only performance specifications in purchasing. These do not require incorporation of amosite if the necessary properties can be attained by other means. Some progress has been made but not enough to permit removal of amosite from the list of strategic materials.

Research on the use of special glass fiber as a substitute for crocidolite asbestos in gas filters is yielding very encouraging results.

The low-iron chrysotile problem is being attacked in several ways. The Cassiar asbestos mine in western Canada is being developed commercially. Preliminary investigation of the asbestos from this deposit indicated that a large percentage of the fiber was of spinning grade and low-iron quality. Early commercial production, which is now in the product-testing stage, supports the preliminary findings and consequently the industry is very optimistic. Output from another source of low-iron chrysotile—the Arizona deposits—is being assisted through exploration loans and purchase programs of Government agencies.

Chrysotile capable of meeting low-iron specifications can also be produced by beneficiating chrysotile of higher iron content. Two types of beneficiated chrysotile have been developed commercially and additional research on beneficiation problems is in progress in both industrial and Government laboratories.

For some applications substitutes, such as synthetic resin and glass fiber, also serve satisfactorily.

The proximity of the large Canadian asbestos mines is a great advantage in preparing for self-sufficiency of the Western Hemisphere in wartime. This source can be supplemented by stockpiling of grades that must be obtained from overseas sources or are required in abnormally large quantity in wartime. Further study of the latter point may justify the inclusion of high-iron Canadian spinning grades in the stockpile.

The domestic exploration program mentioned above includes exploration for chrysotile of all grades. Serpentine areas in California and New England are receiving primary attention, but to date no outstanding discoveries have been made.

Research on asbestos synthesis is in an early stage. Various research organizations have reported synthesis of asbestos or asbestiform materials but none has yet attained commercial success. However, fundamental information on compositions, processes, crystal characteristics, and other technology is being accumulated and there is a growing conviction that success ultimately will be achieved.

The Bureau of Mines is participating in the search for natural deposits and is conducting research on substitutes, beneficiation, and synthesis. These are long-term programs that are directed toward the solution of the complex problems involved and thereby greatly reducing the present dependence on foreign sources of supply.

Senator MALONE. Mr. Blue, will you name the materials that you intend to cover in your testimony? First identify yourself for the purpose of the record.

STATEMENT OF DELWIN D. BLUE, ASSISTANT CHIEF, LIGHT METALS BRANCH, BUREAU OF MINES, DEPARTMENT OF THE INTERIOR

Mr. BLUE. I am Delwin D. Blue, Assistant Chief of the Light Metals Branch, Bureau of Mines. I am here to discuss the light metals, aluminum, magnesium, titanium, and their respective ores. I will discuss them under the headings of the metal commodity.

ALUMINUM

Aluminum. All of the commercial production of aluminum is obtained from a naturally occurring ore called bauxite. The term "bauxite" is used to describe the materials containing aluminum oxide in association with other minerals and is not specific for a fixed chemical composition. Bauxites vary from high-grade ores consisting of almost pure aluminum oxide hydrates to ores containing large percentages of other elements, usually iron or silicon compounds, or both.

The self-sufficiency of the United States in aluminum ores is of necessity based on the domestic availability of ores that are amenable to alumina extraction by present-day commercial practice and in existing plants. Since 1942, the reserves of bauxite that can be economically treated have been greatly extended through the development of processing techniques for treating ores of higher silica and iron content than those used in 1942. However, the requirements for bauxite, which were slightly below 1 million tons in 1940, have greatly expanded, and based on an aluminum production of 1.5 million tons by 1954, United States requirements in the near future will be 6 to 7 million tons annually.

In comparison with such requirements the United States known reserves of commercially usable bauxite are limited and based on the present consumption pattern would last about 6 years with the absence of imports or stockpile. Reliance on these reserves in times of war would require greatly expanded mining and shipping operations. Most of the United States reserves of bauxite are located in two counties in Arkansas.

In North America there are no known bauxite deposits outside of the United States. Canada is a major bauxite consumer and all of its requirements must be imported. Thus the accessibility to bauxite for North America in time of war is the same as for the United States. The requirements will be increased to include Canadian consumption of 2 to 3 million tons per year.

Over the past 3 years about 60 percent of the United States and all of Canada's requirements have been imported. From 1947 to February 1952, a small percentage of United States imports were received from Indonesia, but after January 1952 all imports came from the Western Hemisphere countries. Now, the major source of United States imports are Surinam (Dutch Guiana) and Jamaica, with small quantities from British Guiana. Canada imports bauxite from British Guiana and West Africa and mines and processes bauxite to alumina in Jamaica. The opening of the Jamaican deposits has probably placed the United States and Canada, the major Western Hemisphere consumers, in a better strategic position with respect to bauxite because of the shorter supply lines. Mining operations in the West Indies could, in all probability, be expanded to supplant those of the Guianas.

The Western Hemisphere has large reserves of bauxite and as a unit would be self-sufficient.

With regard to United States self-sufficiency in aluminum ores, one of the major requirements is the development of a method, or preferably more than one method, for recovering aluminum from aluminum silicate materials that exist in practically inexhaustible quantities within the United States. Much of the basic technology for such recovery has already been developed on a small scale. Data on the most economical recovery methods, equipment design, plant layout, remain to be determined. Determination of process variations required for treatment of different domestic ores is also required.

A reevaluation of the bauxite reserves in the United States based on technologic developments allowing use of lower-grade ores would be of value in determining optimum usage of the domestic reserves. The quantities of bauxitic materials containing in excess of 15 percent SiO_2 are virtually unknown.

A solution to the problem of producing large quantities of firm low-cost electric energy would strengthen the aluminum industry. During the 1950–54 expansion program the industry turned to a large extent to the use of natural gas as a source of electrical power. This source no longer appears promising for future expansions and a more efficient method for converting low-grade coals and lignites to electrical energy is needed.

Senator MALONE. Do you have a text on aluminum?

Mr. BLUE. Yes, I do. I would like to reserve the privilege of making a further statement.

Senator MALONE. It will be understood that any additional information will be submitted later and the text on aluminum will be accepted as part of Mr. Blue's testimony at this point.

(The information is as follows:)

BAUXITE AND ALUMINUM

SUMMARY

Although aluminum is one of the most abundant elements in the earth's crust, its widespread use in metallic and nonmetallic applications has occurred in the past half century. The term "bauxite" has been applied to the richest naturally occurring materials that consist mainly of hydrated aluminum oxides. Bauxite is used in the production of metal, synthetic abrasives, chemicals, and refractories, and of the total consumption in the United States approximately 80 percent goes into the production of metal.

The physical properties of bauxite are not as important as the chemical analysis. All consumers request a maximum Al_2O_3 content. The most objectionable impurity for alumina production is silica, SiO_2. High iron content is detrimental in some of the minor uses of bauxite. Nearly 90 percent of the alumina is reduced to aluminum. The other alumina is used largely in the production of chemicals and artificial abrasives. Of the industries using bauxite which is not converted to alumina, the abrasive, chemical, refractory, cement, and oil-refining industries are the principal consumers. From this list it can be seen that virtually all of the industries which use bauxite are important to national defense.

In 1951 and 1952 approximately two-thirds of the world production of virgin aluminum metal was obtained from reduction plants located in Canada and the United States. The North American Continent has very limited reserves of bauxite. Canada is totally dependent on imported ore, and the United States imported 60 percent of its 1951 supply (68 percent in 1952). Most of the imported bauxite comes from South America but immense deposits recently discovered in the Caribbean Islands will make major contributions in the near future.

A large expansion of the aluminum and other bauxite consuming industries occurred during World War II and again under the Defense Production Act of 1950 to provide materials for defense. However, the accelerating consumption of aluminum for civilian uses indicates that larger supplies than presently planned will be needed during the next 10 years even in a peacetime economy. The supply of raw materials, in all stages of manufacture, from raw ore to fabricated metal, abrasive grain, high aluminum refractories, and chemical products will become more difficult as consumption increases.

The aluminum industry in the United States and Canada is based on the use of bauxite as the source of the metal. The major steps in the production of aluminum are mining of the bauxite, the extraction of a pure aluminum oxide from the ore by chemical means and the electrolytic reduction of the oxide. While aluminum is the most abundant metallic element, bauxites account for only a minute proportion of the earth's alumina content. Most aluminum occurs naturally in chemical combination with silica but the production of alumina from low-silica bauxite is less complex than from aluminum silicate.

Much research has already been directed toward finding methods of using the vast quantities of lower-grade aluminum-bearing materials as substitutes for bauxite. Alumina has been produced from some of these potential ores, but

methods tried to date have not proven commercially competitive. The Bureau of Mines has recovered alumina from anorthosite and is currently conducting tests to demonstrate the possibility of using this and other aluminum silicates as sources of alumina. Should the United States be deprived entirely of imports and become short of metal-grade bauxite, the next best alternative now seems to be the use of low-grade bauxites. The term "low grade" is a general term arbitrarily applied to relatively high-silica bauxite. Since there are materials of silica contents ranging from currently acceptable grades of bauxite to clays in which the silica exceeds the alumina, and since the quantities of reserves become greater with the increase in silica content, the transition to using low-grade ores could be made gradually. Additional processing facilities would be needed at the alumina plants and investment and production costs would be considerably greater.

Two of the six alumina plants in the United States use domestic ore. While known domestic reserves of bauxite may last 20 or more years at the current rate of depletion, complete dependence on domestic material would exhaust the supply in 5 to 10 years.

Jamaica and the Guianas are the chief sources of imported bauxite and, since the large Canadian aluminum industry receives much of its bauxite from the same foreign sources as the United States, consideration must be given to her needs in evaluating the life of the reserves of Caribbean countries.

WORLD PRODUCTION

World bauxite production in 1951 totaled 10,984,000 (12,837,000 in 1952) metric tons. Surinam produced 2,671,000 tons; British Guiana, 2,035,000 tons; United States, 1,878,000 tons; and France, 1,124,000 tons. Jamaica did not begin production until 1952, when 265,000 tons were shipped to the United States. Alcoa and Reynolds are the two largest domestic producers. Although most of the other producers are affiliated with chemical and abrasive companies, the Dulin Bauxite Co., the third largest producer, is an independent operator. In Surinam, Alcoa is the largest company. N. V. Billiton, a Dutch company, has supplied the United States with bauxite from Surinam and Indonesia in recent years. Reynolds and Kaiser have begun large-scale mining in Jamaica, and the Aluminum Company of Canada will soon produce bauxite and convert it to alumina in Jamaica before shipping it to British Columbia, Canada. This Canadian company also has begun importing bauxite from new operations in French West Africa.

This company has long been the leading bauxite producer in British Guiana. The United States has depended on imports for about two-thirds of its bauxite supply during the last 5 years. If current plans of the 3 major aluminum producers are realized, domestic production will remain at about 2 million tons while imports from Surinam and especially Jamaica will increase substantially during the next 2 years. Most of the exports, which are insignificant by comparison with imports, are shipped to Canada for the production of crude abrasive oxide which is returned to the United States.

Both metal-grade and refractory-grade bauxite are on the purchase list of strategic materials for the national stockpile. Government allocation controls have not been in effect since World War II.

Since most bauxite is either consumed by the mining companies or their affiliates or purchased under long-term contracts, competitive prices are not generally available. Further, in view of the varying analyses and degrees of processing, it is impractical to quote exact prices for bauxite. For comparing bauxite in its various states of preparation, however, the average value of crude domestic bauxite is near $6 per long ton, dried bauxite near $9, and calcined bauxite near $20.

Recent data on mine production costs are not available. Lessors of bauxite properties receive royalties ranging from 40 cents to over $1 per long ton, depending on the grade of ore and other special factors such as difficulties of mining. In Arkansas, a State severance tax of 10 cents per short ton is also levied.

WORLD RESERVES

The world's presently known reserves of bauxite are estimated at 1.6 billion metric tons. The Western Hemisphere has about 40 percent of the total reserves; Western Europe, exclusive of Russian satellite nations, and Africa, about 30 percent; Russia and her satellites, including China, about 25 percent; and the rest

of Asia, the Pacific islands, and Australia, the remainder. Consuming countries within each of these areas generally rely on bauxite producers in the same region. Since the largest reserves are located in Jamaica, Hungary, Gold Coast, Brazil, and Yugoslavia, and other countries with little or no aluminum production, it can be seen that the present leading aluminum producers must depend on imports for their long-range ore supply if substitute materials are not used.

There has been much interest recently directed toward locating aluminum plants in the underdeveloped areas in which the bauxite is located, in order to reduce freight charges and to relieve the competition between hydroelectric power consumers in other countries. Bauxite reserve estimates are frequently inaccurate because of incomplete data and uncomparability of the various grades; however, the following estimate indicates the magnitude of reserves in the areas from which the United States and Canada now receive bauxite.

	Millions of tons
United States	35
Jamaica	320
Haiti and Dominican Republic	30
Surinam	45
British Guiana	55
French West Africa	5

Other potential sources include the large reserves of Brazil, 190 million tons, and the Gold Coast, 230 million tons. The size and proximity of the Jamaican deposits have done much to allay the fears of being cut off from metal-grade ore supplies during wartime. Although the Jamaican and low-grade domestic bauxites require slightly different equipment to produce alumina, use of the national stockpile should allow sufficient time for converting plants now using South American ore. Alumina plants in operation or under construction in the United States are listed below:

Company	Location	Bauxite source	Capacity (short tons)
Alcoa	Mobile, Ala	Surinam	837,000
Do	East St. Louis, Ill	do	328,500
Do	Bauxite, Ark	Arkansas	401,500
Reynolds	Hurricane Creek, Ark	Arkansas-Jamaica	725,000
Do	La Quinta, Tex	Jamaica	365,000
Kaiser	Baton Rouge, La	Jamaica-Surinam	780,000

Most bauxite is mined by open-pit methods both in the United States and abroad. Since additional earth-moving equipment can usually be added easily, the capacity of the mining operation is therefore a function of the milling facilities, which are usually adjacent to the mines. Bauxite is dried at the mine when long shipments to the alumina plants are involved. Ore for the abrasive plants and some of the minor uses is calcined. Beneficiating, other than washing, is practiced in only a few instances. The Bayer process and variations of it are used almost universally in the production of alumina. Briefly, this process consists of dissolving the alumina in a caustic soda solution to separate the alumina hydrate from its impurities. The alumina hydrate is subsequently precipitated from the sodium aluminate liquor. Since alumina and soda are lost in proportion to the silica which has to be discarded, a sintering step had been devised to recover more of the valuable components when treating high-silica bauxite. The alumina plants at Hurricane Creek, Arkansas, and Bauxite, Arkansas, have these sintering facilities.

SECONDARY ALUMINUM

Supplementing the production of primary aluminum is the production of secondary metal. In 1949–52, secondary aluminum accounted for approximately 20 percent of the metal available. Any major change in the production pattern will have a decided effect on the proportion of scrap available. During World War II the recovery of aluminum from new scrap reached 45 percent of the primary production in 1944. In 1946, 1947, and 1948, a large quantity of aluminum was recovered from wrecked and obsolete aircraft and other ordnance materials. Imports of scrap were negligible prior to World War II but at the

end of the war large quantities were available and represented a cleanup of war materials. Imports of scrap have declined since 1948.

The availability of scrap affects the demand for primary aluminum and thereby the demand for bauxite. However, during periods of abnormally accelerated aluminum fabrication for armaments, the production and return of scrap is dependent on the production of primary metal. Aluminum used for military equipment tends to return as scrap very quickly after the cessation of hostilities and thus no long-term scrap market has yet developed as in metal industries such as iron and steel.

STOCKPILING

The accumulation of a national stockpile of aluminum, bauxite, and cryolite (necessary for the electrolysis of alumina) is only a partial and short-range solution to the supply problems. The national stockpiles of aluminum and bauxite are being accumulated to serve different purposes; bauxite is being stockpiled to serve as an ore source during the calculated time lapse necessary to convert the bauxite consuming industries to the use of domestic bauxite; the aluminum stockpile is to be used to supply demands at the beginning of a wartime period until domestic production capacity or other supply sources can be expanded. The accumulation of bauxite, thus, represents a measure of security with respect to one raw material. An aluminum stockpile has manifold advantages; it represents a large stockpile of electric power, ocean transportation, domestic transportation, time and labor; it gives assurance to the military services that aluminum could be used for purposes that would best serve the military effort; it eases and facilitates conversion to a war economy and since storage costs are low, recent experience in increased costs of basic materials suggests that financial savings may be realized.

CANADA

There are no known occurrences of bauxite in Canada, but imported ores support the world's second largest aluminum-smelting industry. The principal producer, Aluminum Company of Canada, Ltd., has four plants in southeastern Quebec, three of which utilize the hydroelectric power developed by the St. Maurice, Saguenay, and Peribonka Rivers. Canada's production in 1952, all from Aluminum Company of Canada plants in Quebec, was 499,787 short tons, which is slightly above the previous peak achieved in 1943.

Developments now under way at Kitimat, British Columbia, will ultimately double Canadian aluminum production capacity. Ore supply for this plant is being prepared on the island of Jamaica, British West Indies, which reportedly possesses the world's largest reserve of bauxite. The new smelter is expected to commence operation in 1954 at an initial rate of 90,000 tons per year.

Domestic consumption of ingot aluminum is less than 100,000 short tons annually. Most of the surplus is exported under Government purchase contracts to United Kingdom and United States. The United Kingdom received 62 percent of total exports in 1952, while United States took 28 percent. In the previous year the ratios were respectively 53 and 30 percent. Canada continued in 1952 as the major foreign supply of aluminum to the United States and accounted for 86 percent of the total tonnage of crude, semicrude, and scrap imports.

LATIN AMERICAN SOURCES

Brazil

Complete recent figures for Brazilian bauxite production are not available. In 1949 its output was 16,213 metric tons. At least 5,000 tons were exported to Argentina in 1950, and 8,849 metric tons in 1951, from Poços de Caldas. The aluminum plant at Ouro Prêto started operations in December 1951 and presumably bauxite is being mined to supply it. This plant has an annual capacity of 2,000 tons of aluminum, and another plant being built near São Paulo will have a capacity of 7,000 tons, using Poços de Caldas bauxite. In 1950, the Poços de Caldas deposits were estimated to contain 165 million tons of a total Brazilian reserve of 190 million tons of 59 percent Al_2O_3 ore, the highest of the low-iron type in the Western Hemisphere. Other deposits are known in the states of Minas Gerais, Espirito Santo, Bahia, and Rio de Janeiro. Most of the Brazilian-mined bauxite is used in water-purification plants rather than as an ore of aluminum. High transportation costs have retarded the expansion of mining.

British Guiana

After Surinam, British Guiana is the world's largest bauxite producer. Its 1952 production was 2,387,938 long tons, highest in its history. Reserves were estimated in 1953 to be 55 million tons of 61-percent Al_2O_3 ore. The deposits of major economic importance occur in the coastal plain region, about 60 to 80 miles inland, on the Demarara, Essequibo, and Barbice Rivers. The ore bodies are irregular masses ranging in thickness from a few feet up to 30 feet. The thickness of overburden is also variable, reaching as much as 100 feet in some places. All of the ore is dried and some of it is calcined prior to shipment. British Guiana is a major bauxite supplier to Canada, a minor one to the United States.

Surinam

Surinam, the world's largest bauxite supplier, produced 2,671,330 metric tons in 1951, and 3,153,790 metric tons during 1952, including small quantities of chemical-grade and abrasive-grade ore. Reserves in 1953 were reported to be 45 million tons of 59-percent Al_2O_3 ore. The commercially important deposits lie in a zone between the coastal belt and the foothills, 20 to 30 miles from the coast, close to Moengo, and Paranam. They vary from small occurrences up to deposits several hundred yards wide and several miles long. Their thickness ranges from a few feet to 26 feet and the cover from zero to more than 60 feet. All of the ore is dried and some of it is calcined. Most of the Surinam bauxite goes to the United States, minor portions to Canada. Both Surinam and British Guiana bauxites are transferred from shallow draft to oceangoing boats at Trinidad.

Venezuela

Discovery of bauxite has been announced in the State of Bolivar, Venezuela, but the deposits have not been examined sufficiently to permit their evaluation.

Haiti and Dominican Republic

Lateritic soil with alumina content high enough to justify mining was found in Haiti and the Dominican Republic in 1943 soon after the bauxite discovery in Jamaica. In Haiti the ore is found on the Rochelois Plateau for a length of about 4½ miles. Average mineable thickness is considerably less than 25 feet. In both countries the ore bodies are being prepared for mining, with the probability that commercial shipments will begin in 1954. The 2 countries together have reserves estimated at 30 million tons of 47-percent Al_2O_3 ore.

Jamaica

Lateritic aluminum ore was discovered in Jamaica in 1942 near Claremont in the parish of St. Anne. Exploration has developed at least 315 million tons of ore containing 50-percent Al_2O_3 (the world's largest reserve) in the parishes of Manchester, St. Elizabeth, and St. Anne, at elevations from 250 to 2,000 feet above sea level. Average mineable thickness is about 25 feet. All the deposits are within 15 miles of the coast and some large tonnages are within 6 miles of it. After several years of preparation, commercial mining was started in mid-1952, with a planned production of 750,000 tons per year. The West Indian mines have a much better strategic position with respect to the United States than do those of the Guianas. Reynolds Jamaica Mines and Kaiser Bauxite are producing bauxite for export to the United States; Alumina Jamaica, Ltd., alumina for export to Canada.

ASIA

India

Deposits of bauxite are widely distributed in India, the major occurrences being in Bihar, Bombay, Madhya Pradesh, and Madras and Arissa States. Most of the Indian bauxite is an aluminous laterite. Reserves have been estimated as high as 250 million tons, but high-grade material (above 50 percent Al_2O_3) may be of the order of 25 million tons.

Annual production in 1950 and 1951 have been 65,000 and 68,000 long tons, respectively, from mines in the above-mentioned states. Production capacity is much more than current output and India can export bauxite if there is demand.

China

Alumina-bearing ores of varying composition occur in widely separated areas throughout China. Reserves have not been fully explored nor accurately estimated, but indicated ore resources may total over 50 million metric tons. The major deposits are located in Shantung and Hopeh Provinces, and southern Manchuria, and in southwest China.

Indochina

Resources of bauxite in Indochina, located in northern Tonkin, have been little explored. However, it appears that the ores are extensive and may be of high grade.

Indonesia

Potential bauxite reserves in Indonesia exceed 20 million tons. Yearly production is usually on the order of 500,000 to 600,000 metric tons, mainly from Bintan Island. Other reserves are known to exist on Singkef and Banka Islands. A 55-percent product was shipped to the United States until January 1952, and West Germany received most of the exports during 1952. Indonesia normally contributes about 5 percent of the free-world output of bauxite.

Malaya

Malaya has become the No. 2 producer of bauxite in southeast Asia, next only to Indonesia. At present its entire output comes from the Ramunia Bauxite Mine in southeast Johore, where the current production rate is about 100,000 tons per year of very high-grade bauxite, and may be doubled shortly upon completion of a washing plant in 1953. This single deposit may have a life of only 5 years, but there are other large deposits adjacent to the property. The total reserves of high-grade bauxite in Malaya exceed 10 million tons.

EUROPE

Although the reserves of bauxite in Europe are extensive, exploitation has not been undertaken on a very large scale. European bauxite generally contains more iron than Guiana or Dohansas ores used for the Bayer process in the United States. The production of alumina from ores of that class is difficult, and additional facilities would be needed if they were to be used in the United States.

The bauxite deposits are in a zone along the Mediterranean Sea, but in general they are in mountainous areas and transportation is a handicap to low-cost mining.

France

Production of bauxite reached 1,124,000 metric tons during 1951. Of this amount 374,222 tons was exported, principally to the United Kingdom and the Federal Republic of Germany. The bauxite ores contain an average of 60 percent alumina and less than 5 percent silica. Ore reserves are on the order of 50 million tons, of which two-thirds are in the Department of War.

Italy

Italian reserves of bauxite are estimated to be more than 5 million tons. The 1952 production of bauxite, 281,458 metric tons containing 54 percent alumina, was not sufficient to supply the requirements of the aluminum industry in northern Italy, and 195,399 tons were imported. Domestic ores are high in iron oxide.

Greece

The reserves of bauxite ores in Greece are about 60 million tons, of which one-sixth is close to the sea and available for lower cost transportation, however, because of the monohydrate composition of the ore, its use is confined to European countries.

Production during 1952 was 348,591 metric tons. As there is no aluminum smelting industry in Greece, the output is exported. Most of this bauxite goes to the Federal Republic of Germany, but some has been shipped to the United Kingdom and other countries. The analysis varies from 52 percent to 55 percent alumina and about 18 percent iron.

Yugoslavia

The workable reserves have been estimated as 100 million tons. The deposits are in scattered groups along the coast, on some islands, and as far inland as 150 kilometers. All of the bauxite is high in iron.

Production was 577,196 metric tons during 1952. Nearly all was shipped to Germany, but some went to the Swiss-owned plant at Porto Marghera, Italy. There is a new smelting plant near Strnisce, Yugoslavia.

Hungary

The ore reserves have been reported to be larger than in any other country in Europe, but reliable data are not available, although 250 million tons is a com-

monly accepted estimate. There is an alumina plant of about 50,000 tons annual capacity at Almasfuzito.

SMELTING PLANTS

The production of aluminum metal in Western Europe during 1952 is estimated at 442,990 metric tons, which is slightly more than half of the output in the United States. France was the largest producer with Germany second; Italy and Norway each produced about 52,000 tons.

TARIFF

The duty on bauxite in crude or dried form is 50 cents per long ton. Calcined bauxite imported for refractory use is dutiable at $1 per ton; otherwise, calcined bauxite is taxed at 15 percent ad valorem. The tariff on alumina is one-fourth cent per pound. The duty on bauxite is so small it has little effect in restricting imports or on the final price of aluminum. There is no duty on bauxite or alumina imported into Canada.

The price of virgin aluminum has shown a steady decline when compared to other major metals. The Tariff Act of 1930, the last general tariff act, prescribed duties on aluminum as follows: Crude (pig and ingot), 4 cents per pound; scrap, 4 cents per pound; and semifabricated shapes, 7 cents per pound. These duties were successively lowered in 1939 by trade agreements with Canada and the United Kingdom, in 1948 as a result of the Geneva agreement, and in 1951 as a result of the Torquay agreement. In 1952 the duties were 1½ cents per pound for crude and scrap aluminum and 3 cents per pound for semifabricated shapes. In addition to this established trend for lower duties on aluminum the duty on imported scrap was suspended by acts of Congress from March 1942 to June 1949, and from October 1950 to June 1953.

Imports of aluminum have been principally in unfabricated form, chiefly primary ingot. Assuming that the primary purpose of tariff levies is for the protection of the United States industry, the duty is primarily directed at Canadian imports. Available information shows that Canada is the only aluminum-producing country with production costs below those of the United States. The lower Canadian production costs are due largely to lower power costs. Aluminum, Ltd., has the largest privately owned hydroelectric power system in the world. Additional savings are possible because of the peculiarly ideal geographical concentration of production facilities at tidewater ports; alumina and reduction plants are located in adjacent areas with resultant lower transportation costs. Canada exports over 80 percent of its aluminum production. Historically, the price of aluminum ingot imported from Canada (including the tariff) to the United States has been pegged at the going domestic price.

The duty on scrap aluminum appears to be based on primary (crude) rates and has been suspended whenever demand was greater than supply.

Bauxite consumed in the United States, 1950–51, by industries, in long tons (dried bauxite equivalent)

Industry	1950			1951		
	Domestic	Foreign	Total	Domestic	Foreign	Total
Alumina	1,317,829	1,573,285	2,891,114	1,563,663	1,801,260	3,364,923
Abrasive	97,075	98,527	195,612	122,644	181,792	304,436
Chemical	95,391	67,610	163,001	90,568	78,954	169,522
Refractories	7,097	25,406	32,503	14,886	33,687	48,573
Other	34,990	8,084	43,074	53,749	4,464	58,213
Total	1,552,382	1,772,922	3,325,304	1,845,510	2,100,157	3,945,667

Bauxite consumed in the United States, 1951-52, by industries, in long tons (dried bauxite equivalent)

Industry	1951			1952		
	Domestic	Foreign	Total	Domestic	Foreign	Total
Alumina	1,563,663	1,801,260	3,364,923	1,382,041	2,339,588	3,721,629
Abrasive	122,644	181,792	304,436	60,546	194,269	254,815
Chemical	90,568	78,954	164,522	75,670	82,119	157,789
Refractory	14,886	33,687	48,573	13,518	39,861	53,379
Others	53,749	4,464	58,213	52,439	840	53,279
Total	1,845,510	2,100,157	3,945,667	1,584,214	2,656,677	4,240,891

Salient statistics of the aluminum industry, 1940–52

	1940	1941	1942	1943	1944
Primary production...short tons	206,280	309,067	521,106	920,179	776,446
Value	$75,292,000	$100,395,000	$150,768,000	$265,380,000	$222,416,000
Price...cents per pound	18.7	16.5	15.0	15.0	15.0
Secondary production short tons	80,362	106,857	198,492	313,961	325,645
Imports	$5,160,000	$3,828,000	$37,124,000	$41,817,000	$30,323,000
Exports	$22,437,000	$6,873,000	$26,865,000	$67,217,000	$89,796,000
World production...short tons	916,000	1,216,000	1,644,000	2,123,000	1,876,000

	1945	1946	1947	1948
Primary production...short tons	495,060	409,630	571,750	623,456
Value	$140,864,000	$115,812,000	$161,626,000	$180,755,000
Price...cents per pound	15.0	15.0	15.0	15.7
Secondary production...short tons	298,387	278,073	344,837	286,777
Imports	$99,370,633	$12,463,960	$6,603,722	$42,203,519
Exports	$9,906,041	$20,284,053	$52,231,972	$43,219,940
World production...short tons	958,000	870,000	1,189,000	1,398,000

	1949	1950	1951	1952
Primary production...short tons	603,462	718,622	836,881	937,330
Value	$190,303,000	$235,977,000	$304,998,000	
Price...cents per pound	17.0	17.7	19.0	19.5
Secondary production...short tons	180,762	243,666	292,608	[1] 307,000
Imports	$36,815,965	$68,565,400	$63,465,000	$61,769,000
Exports	$32,924,653	$22,153,000	$19,260,000	[2] $12,888,000
World production...short tons	1,442,000	1,631,000	1,971,000	2,650,000

[1] Preliminary.
[2] Not strictly comparable due to changes in classification.

Senator MALONE. Did I understand you to say that there is no question about the self-sufficiency of the Western Hemisphere?

Mr. BLUE. That pertains to bauxite which is the high-grade aluminum ore.

Senator MALONE. And there has been much more material made available in this country through improved methods of handling certain types of ore.

Mr. BLUE. That is true. During World War II, the bauxite which was regarded as commercial could contain a maximum of 7- to 8-percent silica. That has now been raised to over 15 percent through changes in the processing of that ore.

Senator MALONE. How do the reserves of bauxite that are usable now under the new processes compare with the reserves that we had prior to World War II in tonnage?

Mr. BLUE. They are much greater now, and really I do not think we know what the reserves of treatable bauxite by the new processes

are since there has never been any concerted effort to determine what the reserves are when the silica is above 15 percent, and they are presently using bauxite above 15 percent.

Senator MALONE. One of the phenomena, if I may call it that, over the last 34 years which generally disappoints the people that put out scare ads that we are out of this material and we have 1 year's supply or 2 years' supply, is that the laboratory experiments going on continually make other grades of material available, is that not true?

Mr. BLUE. That is right.

Senator MALONE. I know of no strategic and critical material of which we do not have more supplies available at this time than we had 25 years ago. According to many people we have been out of them all that time. But the supply has continually increased, and the reserves have increased. The word "reserves" has been misunderstood.

An engineer when talking about reserves is very conservative and talks about the known reserves.

Mr. BLUE. Known and inferred by the geological environment.

Senator MALONE. But he does not include the reserves that experience shows are nearly always found when the profit incentive is there to find them and which are found as the mining progresses.

Mr. BLUE. That is right. I think a good example of that was made in bauxite. Jamaica has been settled a long time. It now has what is regarded as the largest single body of known reserve of bauxite in the world, 320 million tons. Yet they were unknown prior to 1940.

Senator MALONE. What is the approximate tonnage annually?

Mr. BLUE. Consumption is increasing all the time. When the aluminum expansion program is completed, which will be accomplished in the next year or so, we will be using between 6 and 7 million tons a year.

Senator MALONE. 300 million tons of known material is quite a lot of known material.

Mr. BLUE. That is in Jamaica.

Senator MALONE. I might ask you, too, about Haiti?

Mr. BULE. Yes; there are bauxite deposits in Haiti and the Dominican Republic.

Senator MALONE. We have had an epidemic over the period of the last 20 years of scareheads scaring the American people. They do not explain that experts in each particular line are continually employed in the laboratory and in exploration. They simply read the reserves of each one of the known mining companies, and add the reserves. The President probably put it out having in the back of his head the tax collector, and tells the American people with all the authority of his office that "You are just on the verge of desperation unless we make a treaty with some nation 10,000 miles away." In other words, that we are just about to pass out of the picture and cannot defend ourselves.

Of course, engineers understand that sort of talk, but unfortunately the public does not. We therefore have developed over the last 20 years a sort of complex that we are dependent upon the farflung nations of the world, mostly the colonial slave nations and that we should save what we know we have in our own Nation and destroy our economic structure in so doing. I am happy to have men of your type come before this committee as you know what you are talking about when you give us this material. Proceed with your testimony.

MAGNESIUM

Mr. BLUE. The next subject is magnesium.

Virtual United States self-sufficiency in magnesium is assured because of unlimited supplies of sea water which contains an estimated thirteen one-hundredths of 1 percent of magnesium. It is estimated that if magnesium were taken out of the seas at the rate of 100 million tons a year for a million years, the concentration would drop to twelve one-hundredths of 1 percent, assuming that no more magnesium washed into the ocean in the meantime.

Magnesium is produced from sea water by the electrolytic process. Although this method has proven thus far to be the most economical for production of magnesium, the shortage of power during World War II impelled the Government to build thermic reduction plants in order to obtain the necessary quantity of magnesium during that emergency.

Five of the Government-owned magnesium plants which were built during World War II are silicothermic plants which utilize high-grade dolomite as the source of magnesium, and 75 percent grade ferrosilicon as a reducing agent. The silicothermic plant in Canada also utilizes dolomite as the source of magnesium.

Dolomite (high grade) containing 40 to 46 percent magnesium carbonate, is found throughout the United States and Canada. Ferrosilicon, the reducing agent, is being produced for a wide range of industrial uses in the United States, in the States of Washington, South Carolina, Tennessee, West Virginia, and California.

Although production costs of magnesium in Government-owned silicothermic plants during their short time of operation—which is a batch production process—have been 50 to 70 percent higher than in electrolytic plants, the thermic plants have proven their value in times of emergency. The thermic plants can be shut down and started up quickly at less expense than electrolytic plants of like capacity, and their plants may also be used for thermal reduction of other metal ores, such as those of sodium and calcium. The furnaces may be heated with coal, coke, oil, or gas.

Electricity is required only for producing ferrosilicon, which averages about 4½ kilowatt-hours per pound of magnesium as compared to 10 kilowatt-hours per pound for electrolytic magnesium.

There are no apparent raw-material supply problems connected with magnesium production other than electrical energy, if this is considered as a raw material. Additional research on thermic-production process might well lead to a competitive thermal magnesium with a simultaneous reduction in electrical energy requirements. The overall and long-range problem with respect to magnesium is not one of self-sufficiency. The problem is to develop the properties and uses of this metal, through the development of new alloys with improved physical properties, and the development of alloying, fabricating, and finishing techniques so that it will find a place in the metals economy commensurate with its availability.

Senator MALONE. I will ask you at this point whether a large plant was built at Henderson, Nev., to produce magnesium?

Mr. BLUE. The Henderson plant used magnesite.

Senator MALONE. And the raw material used is also located in Nevada.

Mr. BLUE. That is right.

Senator MALONE. As a matter of fact, it started the town of Henderson in World War II, which is now using all the Hoover Dam power we had arranged to withdraw, all of the Davis Dam power that we could withdraw, and we are begging for more power now for the titanium industry, and other chemical electrical processes. I merely mention that at this time to illustrate what you can do when you have to do it.

Mr. BLUE. That is right.

Senator MALONE. So you are not, as a matter of fact, dependent on foreign nations at all in many of these fields. You might be dependent on a foreign nation because it had not been important enough to do it at home.

Mr. BLUE. That was particularly true in the case of magnesium, when it was a small-tonnage consumption item.

Senator MALONE. Up to that time.

Mr. BLUE. Prior to World War II. During wartime it increased about tenfold.

Senator MALONE. Do you have a text?

Mr. BLUE. Yes, sir.

Senator MALONE. The text on magnesium will be accepted and appear in the record at this point as a part of Mr. Blue's testimony.

(The information is as follows:)

MAGNESIUM

During the past 35 years the magnesium industry has expanded on a scale unparalleled by any major basic metals industry in the United States. Commercial production of magnesium in the United States began in 1915, shortly after imports from Germany were cut off. That year, United States production and consumption was reported as 44 tons. In 1952, the industry reported consumption of 44,000 tons, an increase of 1,000 percent. This expansion is due primarily to the strategic value of this lightest of the structural metals for military use. In 1951 and 1952 about three-fourths of the magnesium consumed in the United States was for defense. The production of large castings and sheet for aircraft accounted for the major portion of magnesium used during this 2-year period.

Magnesium can be cast, rolled, extruded, and forged. It has won widespread approval as a substitute for aluminum, copper, zinc, and lead in many installations; all of these are vital defense materials. The sacrificial use of magnesium for cathodic protection of such steel structures as the hulls of ships and of water, oil, and gas pipelines, is saving thousands of pounds of steel each year. The relatively new use of magnesium as a reducing agent in production of titanium and zirconium, which in the past amounted to a few hundred pounds per year, has expanded to several thousand tons per year.

The abundance and wide distribution of the principal magnesium-rich minerals, dolomite, magnesite, brucite, and olivine, would make the United States self-sufficient in magnesium even without the limitless supply known to exist in the oceans that border the United States. Some or all of these raw materials are available throughout the world; but technological development in production and use of magnesium is backward or absent in a number of countries. About 50 percent of the world supply of magnesium for 1952 was produced in the United States. Magnesium output in the United States rose from 11,598 tons in 1949 to 105,821 in 1952; consumption rose from 11,947 tons to 50,000 in that period, in the United States.

Magnesium is a chemically active metal that unites readily with many other elements, and a high expenditure of energy is necessary to set it free. Two processes of reduction—electrolytic and silicothermic—are now employed in the United States on a commercial scale. The electrolytic plant at Freeport, Tex., with annual productive capacity of 26,000 tons of primary ingot, is the only privately owned plant in the United States.

Six of the seven Government-owned magnesium plants were reactivated in 1951; two are electrolytic plants. This brought productive capacity in the United States to 124,000 tons. It has been necessary to stockpile magnesium because the privately owned plant could not produce enough primary magnesium to fill

present requirements for defense. Electric-energy requirements for production in the large electrolytic magnesium plants are high. Electric energy is always scarce during wartime emergencies. Thus, a stockpile of primary magnesium ingot has been developed as rapidly as possible, from production in the Government-owned plants, in addition to their production of metal to fill current defense orders.

Secondary magnesium is used in the following forms: ingot, castings, wrought products, component in aluminum and zinc alloys and component in chemicals. The characteristics of magnesium alloys and practice that make their repeated use possible are:

1. The variety of composition and number of alloys are quite small, in that the majority of both cast and wrought alloys are combinations of magnesium, aluminum, manganese, and zinc.

2. The alloys do not ordinarily take up metallic impurities in the melting and casting operations.

3. The flux treating or refining practice invariably used for magnesium melting is adequate to remove surface contamination, dross, and other nonmetallic as well as some metallic impurities.

The annual recovery of secondary magnesium averaged approximately 7,500 tons during 1947–51 compared to an average annual consumption of approximately 16,455 tons of primary magnesium during that period.

The base price of primary magnesium, which had remained at 20.5 cents per pound since January 1943, was increased in June 1950 to 21.5 cents; in July the price advanced to 22.5 cents and in September to 24.5 cents. Effective September 30, 1950, the price of primary magnesium was fixed at 24.5 cents per pound under the price-stabilization law. On March 9, 1953, after the law expired, the price of primary magnesium advanced to 27 cents per pound. Primary magnesium was quoted on the world market in 1952 at 30 cents per pound.

The Office of International Trade exercised export control over magnesium throughout 1952. Tariff rates on magnesium are as follows: Metallic, 20 cents per pound; alloys, powder, ribbon, sheets, tubing, wire, manufactures, etc., 20 cents per pound on magnesium content plus 10 percent ad valorem; and metallic scrap, duty-free.

Increase of commercial peacetime demand for magnesium to hundreds of thousands of tons annually depends upon whether various technologic and economic disadvantages of the metal are overcome.

The domestic supply of raw materials in the United States for production of magnesium is sufficient incentive for developing, as rapidly as possible, new equipment and improved techniques to obtain lower costs for producing the metal. Until such improvements are effected, it will be necessary to retain the Government-owned magnesium plants in standby condition. Although the batch operation of the four silicothermic plants results in higher cost of production of magnesium, they have proved their value from the standpoint of national security because they are simple in design and operation. The initial construction cost as well as layaway and reactivation costs, for a silicothermic magnesium plant are about one-third that of an electrolytic plant of like capacity. The thermic plant can be reactivated to capacity production within 4 months, whereas a minimum of 6 months is required to reactivate an electrolytic plant.

ELECTROLYTIC PROCESS

In the electrolytic process, as practiced at the Freeport and Velasco, Tex., plants, sea water is mixed with a slurry of calcium hydroxide or milk of lime. The magnesium in solution in the sea water is precipitated as magnesium hydroxide because of its greater insolubility. The precipitated magnesium hydroxide settles out of the sea water in large settling tanks or Dorr thickeners and is pumped from the bottom of these tanks as a thin slurry containing about 17 percent magnesium hydroxide by weight. Precipitation of the magnesium permits elimination of about 98 percent of the volume of sea water in the first step of the process.

The magnesium hydroxide slurry is filtered and neutralized with hydrochloric acid to form a 15-percent solution of magnesium chloride. The magnesium chloride solution is evaporated and dehydrated to a solution having the approximate composition of $MgCl_2 \cdot 1\frac{1}{2}\ H_2O$. Dehydration is computed in the electrolytic cell where magnesium chloride is decomposed into magnesium metal and chlorine and HCL gases. These gases are recycled to produce hydrochloric acid. The Dow cell is used in all of the electrolytic plants in the United States.

SILICOTHERMIC PROCESS

Dolomite, the source of magnesium in Government-owned silicothermic plants, is plentiful over wide areas in the United States. The usual methods of mining and crushing of rock are followed at the dolomite quarry. The silicothermic process for extraction of magnesium from dolomite is described as follows:

Dolomite is calcined and mixed with ferrosilicon containing 75 percent silicon, and the mixture is briquetted. The briquets are charged into tubular retorts of chrome-nickel steel. The retorts are heated and evacuated. The magnesium oxide in the calcined dolomite is reduced by the silicon, producing magnesium vapor and dicalcium silicate. The magnesium vapor distills from the charge and is condensed into crystals on a removable condenser, the end of which projects from the furnace. By this process metallic magnesium is produced directly from the calcine in one operation. The production of 1 pound of magnesium by the silicothermic process requires approximately 4½ kilowatt-hours of electricity, as compared with 10 kilowatt-hours by the electrolytic process. This is an important factor in times of defense emergency. One ton of magnesium requires about 14 tons of raw dolomite or 7 tons of calcined dolomite and about 1.25 tons of 75-percent grade ferrosilicon. The major disadvantage in the silicothermic process of reduction is batch operation, with consequent high labor costs and production time lost while retorts are cleaned and repaired.

The magnesium crystals produced in the condensers of the silicothermic plants are melted and refined, and the molten metal is ladled into the casting machine to be cast into ingots. Melting and refining losses average 5 to 12 percent of crystal weight.

More efficient rolling and use of magnesium plate during 1952 reduced the volume cost to that of aluminum. Improved production processes will lower costs still further, and broaden the scope of uses of magnesium. New magnesium alloys having greater strength and better resistance to corrosion should be developed as rapidly as possible. Due to the strategic value of this lightest of the structural metals for military use, and as a substitute for other, more scarce metals, the research by the Government, to develop improved processes of production and improved alloys, should be expanded.

Senator MALONE. You may have it understood, too, that any corrections or additions with which you desire to supplement your testimony will be accepted.

TITANIUM

Mr. BLUE. Now we will come to our new metal, titanium. The commercial titanium-bearing ores are ilmenite and rutile. The United States is currently the world's largest producer of ilmenite. About 80 percent of the United States ilmenite requirements is produced domestically, with the remainder coming from India, and in increasing amounts—as titanium slag—from Canada.

Before World War II India was supplying United States consumers with most of their ilmenite. War disruption to seaborne trade gave impetus to the search for domestic supplies with the result that the United States now has the largest single ilmenite-producing mine in the world at Tahawus, N. Y., and that other new domestic properties were developed thereby reducing considerably reliance on foreign sources. Present Canadian operations on production of high titania slag from vast deposits of titaniferous hematite, if successful, will assure the United States of large supplies of raw material for the titanium industry for many years to come.

Senator MALONE. I am very much interested in your testimony because we held 2 days' hearings in Henderson on the titanium production. A 10-ton-a-day contract is held by the Titanium Corp., and the corporation is now producing about 4 tons a day. The Du Pont Co. also holds a 10-ton-per-day contract, and has reached substantial production. We intend to have additional testimony later the produc-

tion of and demand for titanium. We are now securing the rutile used at Henderson from Australia.

Mr. BLUE. Du Pont has a contract for 7½ tons of metal per day, in addition to their privately constructed 2½-ton-per-day plant.

Senator MALONE. Rutile is not too plentiful in the United States, but there are fairly large known deposits, especially beach sand.

Mr. BLUE. Yes; they have small percentages of rutile which are recovered at the same time as the ilmenite.

Senator MALONE. Yes. According to the testimony there is little question of an adequate supply of ilmenite in the United States. It is just a question of the cost of recovery.

Mr. BLUE. That is right. There are large quantities of ilmenite.

Senator MALONE. Probably the reason it is not more plentiful at the moment is because there has been no demand until the last few years, is that true?

Mr. BLUE. That is right.

Senator MALONE. I might say at this point that hearings have definitely been set at Los Angeles for the 3d and 4th of November to hear the plane producers, Douglas, Lockheed, Boeing, and several other producers, as to what would be done in the matter of plane production for national defense and for commercial use if this metal were available in sufficient quanities. They would just simply take the plans off the drafting board and go to work as though they were going to use stainless steel. The head of Wright-Patterson Airfield at Dayton, Ohio, said that instead of this pitiful amount we are presently producing, we could use 100,000 to 150,000 tons a year. In my humble judgment, you men in your research have stumbled into one of the most valuable metals that has ever been discovered in the history of the world.

Mr. BLUE. It has some very unique properties and actually we do not know what they all are yet.

Senator MALONE. You do know it has enough properties that you must have it.

Mr. BLUE. It has some outstanding properties that we know of.

Senator MALONE. Go ahead.

Mr. BLUE. Plans were recently announced for expansion of ilmenite production in Florida. Ilmenite produced as a byproduct from monazite operations in Idaho is presently not being used reportedly because of the long distance of these operations from consumers of this material.

Rutile, the other commercially important titanium ore, is at present not produced domestically in sufficient quantity to meet United States requirements. About two-thirds of present domestic supply is imported from Australia, the major rutile-producing country and only country shipping rutile to the United States for the past 5 years.

Titanium pigments take about 99 percent of the ilmenite consumed in the United States. Rutile is used mainly for welding rod coatings, alloys, and titanium metal. Although rutile, the highest grade titanium mineral, is temporarily being used for production of titanium metal, it is not available in sufficient quantities to support an expanding titanium metal industry. Any major expansion of titanium metal production must be premised on the use of ilmenite or high titania slag. One company is presently using a mixture of titanium minerals separated during their ilmenite producing operations in

Florida. Expansion of titanium metal production to 100,000 tons per year would require almost the entire present United States production of ilmenite.

Senator MALONE. But we can be assured that sufficient tonnage of ilmenite is available to meet almost any desired production.

Mr. BLUE. That is right. Titaniferous minerals exist almost all over the United States. We do not know where they all are or what their concentration is, because the interest in them up to this time has not been great enough to promote the exploration for them.

Senator MALONE. I think that is one of the finest illustrations as to why we have produced insufficient quantities of many other products. The demand has not been sufficient to bring about the exploration necessary to find them.

Mr. BLUE. I think that is certainly true.

Senator MALONE. You are the expert on this. I of course can talk freely because I was not responsible for that particular metal. Do they not say that the mineral used in the production of titanium is about the fourth, fifth, or sixth most plentiful mineral on the earth's surface?

Mr. BLUE. I think it is the fourth most abundant structural metal element in the earth's surface.

Senator MALONE. Go ahead.

Mr. BLUE. High titania slag would be preferable to ilmenite because, due to its higher iron content, ilmenite requires more chlorine than slag in production of the titanium chloride which is used for production of titanium metal.

Senator MALONE. By the way, the products used in addition to the necessary mineral ores are produced right there at Henderson, which makes it a rather unique operation.

Mr. BLUE. Yes, sir.

Although the minerals of titanium are known to be widely distributed in the earth's crust, the efficient utilization of these minerals requires a determination of their location, quantity, grade, and the development of methods for economically recovering the titanium value.

Recent technological developments in the smelting of titaniferous iron ores have increased the prospective sources of titanium for pigment or metal use. A current examination and analysis of all domestic titanium ores are now needed to bring reserve estimates up to date not only for presently developed sources but also those undeveloped heretofore because of lack of feasible processes. The determination of methods for the recovery of byproducts, such as pig iron and vanadium from the titaniferous iron ores or columbium from Arkansas titanium minerals is an important phase of this work which may lead to economic utilization of ores now regarded as marginal.

Senator MALONE. They were marginal until you found a use for the titanium part of the ore.

Mr. BLUE. Here I am speaking of titanium-bearing ores in Arkansas which also contain columbium.

Senator MALONE. They would not be economic to mine just for the columbium.

Mr. BLUE. No; and also not just for the titanium.

Senator MALONE. That is right. But with all of the new materials that can be used, it might be an economic operation.

Mr. BLUE. That is right.

Present domestic production of rutile comes entirely from Florida. In the past production also came from Virginia and Arkansas, although these States were marginal producers reportedly competing with other sources only in periods of heavy demand. Brazil in addition to Australia supplied rutile to the United States during World War II. Receipts from Brazil ceased in 1947. Examinations are needed of domestic placer deposits particularly in the Southeastern States for delineation of reserves of rutile and other related minerals. Exploitation of rutile from rock deposits such as in Arkansas requires development of economically and technically feasible processes for utilization.

The defense expansion goal for production of titanium sponge was increased on August 6, 1953, and calls for an annual output of 25,000 tons in 1956. Production of titanium sponge increased from 495 tons in 1951 to 1,075 tons in 1952 with about 2,200 tons expected in 1953.

Senator MALONE. That corresponds to what I said for the record previously, that approximately 2,400 to 2,500 tons will be produced this year, but contracts have been let for——

Mr. BLUE. Approximately 13,200 tons per year.

Senator MALONE. 7,200 tons when full production is attained.

Mr. BLUE. That is right. They are not in full production. This 2,200 tons expected in 1953 anticipates a higher rate of production during the last half of the year than the first half.

Senator MALONE. That is true. That is sponge material.

Mr. BLUE. That is sponge.

The Government has contracted with the Titanium Metals Corp. of America at Henderson for 18,000 tons of sponge over a 5-year period, with E. I. du Pont de Nemours, at Newport, Del., for 13,500 tons over a 5-year period, and with the Cramet Co., reportedly at Chattanooga, Tenn., for 30,000 tons over a period of 5 years.

Senator MALONE. Have they definitely decided to locate at Chattanooga, Tenn.?

Mr. BLUE. I do not know for sure.

Senator MALONE. I understood there was some question about it.

Mr. BLUE. I believe that is still true. They have tentatively set that as their location.

Contracted capacity is now 12,300 tons per year which together with Du Pont's 900 tons per year privately owned plant gives a total planned capacity of 13,200 tons of titanium sponge per year. Because of the present critical shortage of titanium metal the General Services Administration (formerly Defense Materials Procurement Agency) requested the Bureau of Mines to supplement insufficient production by industry. Under contract DMP–76, the Bureau of Mines will endeavor to produce within a period of 18 months following the date of the contract, April 30, 1953, a minimum of 360,000 pounds of usable titanium sponge. By the end of September 1953, the Bureau had produced about 80,000 pounds under this contract.

Senator MALONE. I was very much concerned about that matter in our hearing in Henderson. We had three of your representatives before the committee at different times. We did not urge them to produce to the point where it handicapped them in their laboratory work in their search for better and more efficient methods for manu-

facturing sponge. They have a process in the laboratory now. They are experimenting on a continuous process.

Mr. BLUE. That is right.

Senator MALONE. Is the contract of the required commercial production in your judgment liable to interfere with the laboratory work necessary to attempt to increase our total production of titanium at a more economical rate?

Mr. BLUE. I think that the present contract with DMP for production of titanium metal will in some respects aid the research work that is going on, because it has given us more money to work with, and there is a certain amount of value in operating a plant which aids in research just the same as the research is of value in operating the plant. It may be true that if we had more money for research that the operation of the plant would handicap our research activities, but my information from Boulder City is that we are efficiently utilizing the research funds that we have for titanium.

Senator MALONE. Testimony showed that there was some advantage to your research work in having such a contract, but that there would be a definite limit as to how much you could produce and still continue your laboratory work.

Mr. BLUE. That is true. That depends on the facilities, funds, and manpower we have.

The present titanium production process, magnesium reduction of titanium tetrachloride, retains the high costs features inherent in batch production processes. Cost reduction by this process may be expected if the technology is developed for a continuous chlorination process to lower the cost of titanium tetrachloride, by production of larger batches, and complete plant integration for electrolysis of magnesium chloride to recover magnesium and chlorine. In addition to reduction in the cost of sponge the cost of milled shapes could be reduced by development of processes to recover titanium scrap.

Extensive research is required on developing improvements in the present process for producing titanium and also on electrolytic and other new methods of reduction.

Considerable power is required in the production of titanium metal. Power required for titanium is about double that needed for electrolytic production of magnesium. This large power requirement is understandable in view of the fact that over a pound of magnesium is required for the production of 1 pound of titanium. Large-scale expansion of the titanium-metal industry will undoubtedly have to be centered at sites having access to large quantities of low-cost power, and would require definite scheduling of available or potential power sources.

Senator MALONE. It was testified that 16 to 23 kilowatt-hours of power are necessary to produce a pound of titanium, depending upon the process and the latitude of work included in the process. With sponge selling for $5 per pound the kilowatt-hours, at even a cent a kilowatt-hour, would not be a very great percentage of the cost. Therefore, the power cost was apparently not as important as I had previously believed.

Mr. BLUE. At $5 a pound it is not, that is true.

Senator MALONE. The availability of the power is one of the greatest drawbacks to production right now.

Mr. BLUE. That is true for all our light-metal commodities. They are all large power consumers.

Senator MALONE. I am interested in your statement that the price may be lowered. Which production process has the greatest prospect of bringing down the price of sponge?

Mr. BLUE. I think the greatest prospects are in developing a technology for a continuous process as against a batch process with small batches.

Senator MALONE. And you are working on that in your laboratory at Boulder City?

Mr. BLUE. That is right.

Senator MALONE. And that is the same laboratory that perfected the process in the beginning, at least to the point where you let contracts.

Mr. BLUE. We worked on titanium at other laboratories than Boulder City, but that is where it is centered now, and where we did the large scale work.

Senator MALONE. Then the text on titanium and rutile, the raw materials used in the production of titanium, will be accepted and appear at this point in your testimony.

(The information is as follows:)

TITANIUM

SUMMARY

Metallic titanium owes its importance to an unusual combination of properties—lightness, strength, and resistance to corrosion. Ductile titanium was virtually a laboratory curiosity a short time ago. Commercial production, based on the process developed by the Bureau of Mines, was begun in 1948 and increased from 10 tons in that year to 1,075 tons in 1952. Titanium is important in the manufacture of improved military equipment; its domestic ores are relatively abundant.

Titanium is a low-density, silver-white metal between silver and stainless steel in color. The density of titanium is 0.16 pound per cubic inch, 60 percent heavier than alumium but only 56 percent as heavy as alloy steel. Titanium alloys are much stronger than aluminum alloys, having tensile strength and hardness approaching that of many alloy steels. The strength to weight ratio at ordinary temperatures exceeds that of either aluminum or stainless steel. Titanium alloys also have unusual resistance to fatigue and great impact strength. Titanium metal is more resistant to corrosion than aluminum and as resistant as stainless steels; it is particularly resistant to sea-water corrosion and marine atmospheric weathering.

The chief disadvantages are high cost, difficulties of fabrication, and excessive reactivity at high temperatures. Although the melting point of titanium—3,150° F.—is extremely high, it absorbs oxygen and nitrogen and becomes brittle above 1,000° F.

Tonnage production and improved processing techniques are making more and more titanium available for new applications in the following civilian and military services:

1. Airframe skins and structures where intermediate temperatures or corrosion problems are found.
2. Aircraft powerplants where temperatures up to 1,000° F. are involved.
3. Naval or marine applications in which the complete resistance to sea-water corrosion exhibited by titanium is unique.
4. Ordnance and other equipment in which a combination of light weight, corrosion resistance, high strength, and intermediate temperature properties is required.
5. Industrial equipment for which titanium's particular corrosion resistance is desirable.

The outstanding characteristics of titanium suggest numerous other uses. These include surgical instruments, orthopedic appliances, portable machine tools, sporting equipment, such as lightweight noncorroding gold clubs, tennis

rackets and fishing rods, food handling and processing equipment, X-ray tube targets, and textile machinery.

Although titanium is a new metal to industry the large-scale production of its oxide has provided an excellent raw-material base for development of the metal. Titanium-metal development comes at a fortunate time to ease the burden on the earth's dwindling resources. It is one of the "growing metals group" consisting of titanium, aluminum, and magnesium. The relatively large quantity of titanium potentialy available as compared to the small quantity of such metals as copper, lead, and zinc is striking.

Present commercial production of ductile titanium metal is based on modifications of the Bureau of Mines process. Titanium tetrachloride, produced by chlorination of titanium ores, is reduced to the metallic state with magnesium in an inert atmosphere of helium or argon. Most of the magnesium chloride formed during the reaction is drained to prevent slowing the reaction rate. The remaining magnesium chloride and excess magnesium are removed from the spongelike titanium by vacuum distillation. The titanium sponge is consolidated by melting in induction or electric-arc furnaces.

Ductile titanium metal is produced commercially by the Titanium Metals Corp. at Henderson, Nev., DuPont at Wilmington, Del., and on pilot-plant scale by the Crane Co. at Chicago, Ill. Production of ductile titanium metal increased from about 25 tons in 1949 to about 75 tons in 1950, 495 tons in 1951, and 1,075 tons in 1952.

The principal raw materials required for production of ductile titanium metal by the Bureau of Mines process are titanium ore (rutile, titanium slag, or ilmenite), magnesium, chlorine, electric energy, inert gas (helium or argon), and fuel. Major requirements per pound of titanium sponge are 3.5 to 4.0 pounds of ilmenite (or rutile or titanium slag of equivalent titanium content), 5 pounds of chlorine, 1.25 pounds of magnesium, and about 9 kilowatt-hours of electric energy. If the magnesium and chlorine are regenerated, the requirement for magnesium is about 0.2 pound and for chlorine about 1 pound. The energy required for an integrated plant ranges from about 15 kilowatt-hours to 20 kilowatt-hours per pound of titanium sponge, depending on whether fuel or electric power is used for reduction and distillation.

Plant costs for producing ductile titanium metal, under the present technology and small-scale commercial production, are very high. A commercial plant to produce 1 ton of metal per day costs 1.5 to 2 million dollars. A plant to produce 10 tons of metal per day costs about $15 million. This figure is based on the amount loaned by the Government for constructing a 10-ton-per-day plant by each of the 2 present producers.

After the Bureau of Mines demonstrated that ductile titanium could be produced on a pilot-plant scale, E. I. du Pont de Nemours & Co. started the world's first small-scale commercial production of titanium at Newport, Del., in 1948 on a small unit. In 1949 the National Lead Co. also constructed a pilot plant at Sayreville, N. J. Both companies expanded their pilot-plant units through successive stages. By 1952 production by Du Pont reached 2½ tons per day.

The first Government expansion program was initiated in 1951. This program, which recommended construction and operation of two 10-ton-per-day plants with an aggregate rated capacity of 7,200 tons per year, was endorsed by Defense Minerals Administration, later succeeded by Defense Materials Procurement Agency, and accepted by Defense Production Administration. It served as the basis for the first expansion of titanium production and resulted in the construction and initial operation of a 10-ton-per-day plant by Titanium Metals Co. (subsidiary of National Lead Co. and the Allegheny Ludlum Steel Corp.) at Henderson, Nev., and planned expansion by Du Pont to increase its production at Newport, Del., from 2½ to 10 tons per day.

In November 1952 the Defense Production Administration set the goal for production of commercial titanium sponge at 22,000 short tons by the end of 1955. In August 1953 this goal was increased to an annual output of 25,000 tons in 1956. The new production will come from present producers and new organizations, such as the Cramet Co., of Chicago, Ill., one of the leading plumbing and valve manufacturers, who contracted with the Government to produce 30,000 tons over a period of 5 years.

In August 1951 a temporary revolving stockpile was established to maintain capacity operation of titanium-sponge-manufacturing facilities during the present development of military applications. Sponge production, although in excess of that needed for experimental work, was insufficient to permit its expanded large-scale use in military items. To assure an increased supply of titanium and the utilization in the manner most advantageous to the national defense, the

DPA, upon the recommendation of DMA, authorized GSA to establish and maintain a revolving fund of $5 million for purchase and resale of not more than 1 million pounds of titanium sponge at a price not to exceed $5 per pound.

At the end of 1952 the revolving-fund stockpile contained about 300 tons of titanium. Due to increased demand this inventory was depleted by June 1953. The revolving-fund stockpile was set up to provide a temporary reserve of titanium sponge available for resale and is in no way connected with the national stockpile.

Due to the present and anticipated future insufficiency of titanium for defense the DMPA, upon recommendation of the Munitions Board, entered into an agreement in April 1953 with the Bureau of Mines for production of titanium sponge at the Bureau of Mines pilot plant at Boulder City, Nev. The Bureau will endeavor to produce a minimum of 360,000 pounds of usable ductile titanium at a rate of 1,000 to 1,400 pounds per day. The Bureau's production will supplement and not compete with private industry.

Titanium-sponge metal (commercially pure) is quoted at $5 per pound. Milled shapes sell from $6 to about $20 per pound. Prices are expected to decrease with expanded production and through improvement of existing processes or development of new processes.

The Tariff Act of 1930 set the rate on titanium metal at 25 percent ad valorem; this rate was decreased to 20 percent in 1951.

Other countries have reported interest in titanium. England is producing titanium on a small pilot-plant basis; numerous Japanese companies are engaged in titanium research. Small-scale pilot-plant production has been reported in Japan, and one of the Japanese companies has shipped small trial lots to United States consumers.

DOMESTIC RESERVES

Titanium ores are found extensively through the United States, Canada, India, Australia, Norway, Ceylon, Brazil, Sweden, and the U. S. S. R. Large ilmenite deposits occur in Virginia and North Carolina. Extensive deposits of titaniferous iron ores occur in New York, Minnesota, Rhode Island, Wyoming, California, and New Mexico. Other occurrences of iron ores rich in titanium have been reported in North Carolina, South Carolina, Tennessee, New Jersey, Colorado, Montana, and Oklahoma. Rutile and ilmenite, with other minerals, are found in beach sands at many places along the Atlantic, Pacific, and Gulf coasts and also in stream sands; they have been worked mainly in Florida, Idaho, and to some extent in Oregon. Rutile deposits also occur in Virginia and Arkansas.

The Magnet Cove rutile deposit, Hot Spring County, Ark., was explored by the Bureau of Mines; this work revealed an extension of the ore body from the previously mined area.

Laboratory tests at the Bureau of Mines Experiment Station, Rolla, Mo., indicated that an ilmenite concentrate (about 20 percent TiO_2) and iron-ore concentrate could be recovered from the red mud or residue of the Hurricane Creek alumina plant operated by the Reynolds Metals Co.

WESTERN HEMISPHERE RESERVES

Both Mexico and Brazil have extensive deposits of titanium-bearing material, which have not been completely measured to date owing to lack of demand and development. Some ilmenite concentrates are produced in Brazil in connection with monazite-mining operations but have not been shipped since 1948.

WORLD RESERVES

Europe

Norway appears to have the largest reserves of ilmenite in Europe and is producing from the Sokudal mine in southern Norway, which has a measured reserve of 30 million metric tons of 17 percent TiO_2. Other large deposits of titaniferous iron ores are not in production.

Sweden has large, low-grade deposits, about 6 percent TiO_2, which were worked in 1939 to 1945 for export to Germany but are now idle.

Finland, Czechoslovakia, and Italy have large deposits of undeveloped and unmeasured titanium-bearing ores. Both Spain and Portugal have deposits of titanium-bearing beach sands, which are being used for very minor production.

Both rutile and ilmenite are being produced in Africa in minor quantities. Significant reserves appear to exist, particularly for ilmenite.

Asia

Japan is producing small quantities of titanium metal from the titanium slags left from smelting of the iron sands found in the country.

Tariff

Duty-free. The Tariff Act of 1930 placed titanium ores on the free list.

RUTILE

The principal commercial ores of titanium are ilmenite ($FeO.TiO_2$); arizonite ($Fe_2O_3 \cdot 3TiO_2$), referred to by industry as ilmenite; and rutile (TiO_2). Ilmenite ores, used mainly in the production of titanium dioxide pigments, are found extensively throughout the United States. Rutile ores, on the other hand, are present in only a few domestic areas.

The major use for rutile to date has been for welding-rod coatings. Of the total consumption of 18,317 short tons in 1952, 62 percent went into welding-rod coatings, 16 percent was used for alloys and carbide, 2 percent for ceramics, and 20 percent for miscellaneous uses, such as fiberglass and titanium metal. Although rutile is used in the production of titanium metal, it is not available in sufficient quantities to support an expanding titanium-metal industry. Any major expansion of titanium-metal production must be premised on the use of ilmenite or high-titania slag.

Ilmenite, manufactured titanium dioxide, and Tanarc are substituted for rutile in the production of some welding-rod coatings. Tanarc (containing 70 percent TiO_2) is made from titanium slag imported from Canada. Manufacturers claim that the use of these substitutes is limited and that desired characteristics for most welding rods are obtained only with rutile.

Domestic production of rutile now comes from beach-sand operations at Melbourne and Jacksonville, Fla. Rutile was produced from the Magnet Cove rock deposit in Hot Spring County, Ark., until 1944, and from another rock deposit near Roseland, Va., until 1949.

About two-thirds of the present domestic supply comes from Australia, the major rutile-producing country and the only country shipping rutile to the United States from 1948 to 1952. Rutile imports from Australia were 19,550 tons in 1952, establishing a new record over that previously set in 1943. Proved reserves of high-grade Australian rutile deposits total over 800,000 short tons.

World production of rutile in 1952 is estimated at 52,000 short tons; 84 percent was supplied by Australia and 15 percent by the United States. The remaining 1 percent was produced by Brazil, French Cameroon, India, Norway, and Senegal.

After World War II the price of rutile dropped, owing largely to decreased demand. Under the General Ceiling Price Regulation of January 26, 1951, the price of rutile was frozen. The increased world demand for Australian rutile raised the price to such an extent that United States concerns could not negotiate for rutile at these market prices with the ceiling price frozen at a much lower level. Accordingly, amendment 13 to General Overriding Regulation 13 was issued on January 18, 1952, by Office of Price Stabilization. This amendment exempted from price control all sales of imported and domestic rutile ores and concentrates and the allied services of mining and processing such materials. The removal of rutile from price control permitted domestic consumers and dealers to compete with other countries in obtaining this material and allowed domestic producers to continue production by meeting the higher prices requested by the operating companies.

Rutile was in short supply at the end of 1951 and the first part of 1952. In addition to removal of the price ceiling, other actions were taken to remedy this situation. The National Producton Authority announced inventory controls on rutile under NPA Regulation 1, as amended, January 28, 1952, and the Defense Minerals Exploration Administration, under DMEA Order 1, issued March 7, 1952, placed rutile and brookite in the classification of strategic and critical materials and set forth provisions under which the Government would contribute up to 75 percent of the total exploration costs for these materials. By the end of 1952 supply and requirements about balanced. Rutile was removed from the inventory control list September 9, 1952, and DMEA removed rutile and brookite from its strategic and critical list on May 16, 1953.

Rutile is the only titanium mineral or product included in the National Stockpile Current List of Strategic and Critical Materials. Rutile falls under list II,

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which includes materials acquired only through transfer of Government-owned surpluses.

The Tariff Act of 1930 placed titanium ores on the free list.

Senator MALONE. Mr. Blue is still here. I made a note to ask about your progress on aluminum clays and other sources of alumina. If you give us a short outline of the status of these investigations, with a supplemental statement later, if you care to do so, I would appreciate it.

Mr. BLUE. In the previous testimony I gave I said that to obtain national self-sufficiency with respect to aluminum in the United States it would be necessary to develop a process for treatment of low-grade ores, preferably by more than one process. The Bureau of Mines is at the present time working in the Laramie, Wyo., alumina plant on an alkaline-sinter method for producing alumina. It has another project at Albany, Oreg., for carbothermal reduction of aluminum silicates in electric furnaces and then at Bauxite, Ark., it has a small project on methods of upgrading the high silica bauxites in the bauxite area in Arkansas.

We have felt for years in the Bureau of Mines that it is necessary or it certainly should be a part of our program of conservation and efficient utilization of mineral resources to eventually work out a process for recovering alumina from these immense deposits of low-grade materials in the United States.

Senator MALONE. Does that include the clays?

Mr. BLUE. The clays, anorthosite, and numerous aluminum-containing materials that run about 30 percent alumina.

Senator MALONE. What would you say is the status of such work at the present time, as far as practical use in case of emergency is concerned?

Mr. BLUE. Actually, since 1942 not only the Bureau of Mines but the aluminum industry itself have made immense strides in the use of the lower grade ores. The combination process was put into use early in the war for the treatment of high silica ores, or higher silica ores than had been used previously. I took upon this whole thing as a sort of evolutionary process. Originally we could not use ores containing over 7 percent silica, and they did not like to use those. Now we are using ores containing up to 20 percent silica. As time goes on, I think that will be extended to 25, 30, to something like anorthosite, for example, which runs over 40 percent silica and about 90 percent alumina. Silica is greater than the alumina.

Senator MALONE. In other words, you will just gradually encompass these ores containing what you would call impurities through competitive necessity and better methods of working the deposits.

Mr. BLUE. That is right. I think this is the evaluation of the use of low-grade ores, and I think we have made progress in the last few years.

Senator MALONE. You heard Mr. McBride's testimony, which is very interesting to me. I do not know too much about the plant there. I have not studied his testimony, but I think it is well to have it in the record. Are you familiar with the status of the experiments there?

Mr. BLUE. Yes. At the present time we are operating the plant on what we might call a two-phase or discontinuous basis. The reason we are doing this is, first, that in the Laramie area there is not the manpower to run this thing on a sustained basis for a short-term

project. The second reason is that the funds which were allotted to us by the Congress for this purpose would only allow us to run it for a very short period of time on a sustained basis. Approximately 100 tons of calcined alumina have been produced by the Bureau of Mines at the Laramie plant. We are producing alumina by this two-phase operation and that is the method by which we now intend to continue the operation until we have finished this project at Laramie.

Senator MALONE. With no intention of putting you on the spot, or in any way rushing your conclusions, what would you say was the contribution that you have made through these operations? Through these operations, have you advanced the time at which these clays and aluminum-bearing ores can be made, if not commercially feasible under present competitive conditions, at least available in time of emergency?

Mr. BLUE. I am glad you put the question that way, because as far as advancing the time is concerned, I cannot tell you.

Senator MALONE. You cannot state whether the time for commercial use has been advanced?

Mr. BLUE. That is right. I certainly think that the technical information developed here would put us in a better position with regard to constructing or altering plants which are in operation for treatment of these types of ores.

Senator MALONE. If you had to make use of them.

Mr. BLUE. That is right.

Senator MALONE. And you could do it?

Mr. BLUE. Yes, I think we could do it. I think we could have done it some time ago. The more we find out the less waste there is going to be when we have to do it.

Senator MALONE. In other words, it is similar to your experiments in synthetic rubber or titanium or in any other new field. A certain amount of work has to be done in order to obtain a workable process for an emergency and additional work is ncessary to make the process profitable under commercial conditions. Do you think you have really advanced the date with respect to the process being available in a time of emergency?

Mr. BLUE. I think we have advanced the technology as far as an emergency is concerned.

Senator MALONE. The chairman will appreciate it, if you will consult with Mr. Ralston and present a supplemental statement for the record as to your technological progress in recent years and its present status with respect to both commercial and emergency wartime use.

Mr. BLUE. I would like to ask this; you want the status?

Senator MALONE. The status and what you contemplate should be done over the years ahead to continue the work.

Mr. BLUE. Yes, sir; I can do that.

Senator MALONE. You heard my request to Mr. Ralston. I consider him outstanding in the new field. I asked him to aid the committee in determining what recommendations should be made toward obtaining our self-sufficiency of these scarce materials.

Mr. BLUE. I came to work for the Bureau of Mines in 1941 and I worked with Mr. Ralston on this particular project.

Senator MALONE. Then I will count on your furnishing that material.

Mr. BLUE. Thank you.

(The information is as follows:)

The Bureau of Mines has for a long period of time conducted research on the utilization of low-grade materials for the production of alumina. In 1922, a Report of Investigations No. 2393, Production of Alumina From Clay Tests on the Miguet Process, was published by the Bureau of Mines.

At the beginning of World War II when it became obvious that the aluminum requirements of the United States would be increased, the alumina research program of the Bureau of Mines was greatly expanded. An exploration program by the Bureau of Mines and Geological Survey for delineation and determination of United States bauxite reserves was established. As a result of this program the known and inferred reserves of bauxite in Arkansas were approximately doubled, and information on submarginal bauxites and high alumina clays in other parts of the United States was accumulated. Coincident with the bauxite exploration program a research program aimed at development of methods for recovering alumina from low-grade ores was initiated by the Bureau of Mines. Methods for upgrading low-grade bauxites, those with high silica and/or iron content, were investigated. Only a small amount of the domestically occurring bauxitic ores proved amenable to ore beneficiation by ore dressing methods, and although this research generally showed negative results it accented the necessity for developing chemical extraction methods. Both acid and alkaline processes for extraction of alumina were tested and the most promising methods were investigated on a pilot-plant scale. The results of the Bureau of Mines research on processes for producing alumina from low-grade ores were published in 1 bulletin, 1 technical paper, and 12 reports of investigations.

During World War II, the United States Government through the Defense Plants Corporation constructed four demonstration plants to test acid and alkaline alumina extraction processes. At the end of the war, none of these plants had been in operation long enough to test adequately the processes, and when the pressing need for utilizing domestic materials subsided the plants ceased operation. During the World War II period the Bureau of Mines research was not limited to the search for processes of utilizing low-grade ores but was also extended to include research on the development of methods for utilizing aluminum dross and scrap for production of high-grade aluminum.

Bureau of Mines research on the methods for utilizing low-grade domestic ores at the present time is divided into three types of projects; (1) The investigation of methods for upgrading bauxites which are not amenable to present commercial practice so they can be used in established plants; (2) the continuation of the methods of extracting alumina from aluminum silicate materials on a larger scale than has been possible heretofore; (3) the investigation of a process for utilizing siliceous aluminum ores by the direct smelting of these materials in an electric furnace to produce an aluminum silicon alloy. A part of this smelting work was done in cooperation with Apex Smelting Co. of Chicago, Ill., and as an outgrowth of this work, Apex is constructing a smelter for production of master aluminum silicon alloys that can be used to supply both silicon and aluminum in the manufacture of certain specification ingots. Although the consumption of this alloy is limited by the quantity of silicon required for the various silicon containing aluminum alloys, additional aluminum will thus be supplied from noncommercial ores along with silicon which otherwise would have to be produced by a separate process.

Although the problem of utilizing aluminum silicates or the commercial production of alumina has not been solved, the investigations which have been carried on by the Bureau of Mines have established a basic pool of information which could be used for designing plants to use these ores at such time as it became necessary. The present work being done at Laramie, Wyo., in a demonstration size plant for recovering alumina from anorthosite will add significantly to the basic information required for design of commercial scale plants.

Research and development on aluminum, aluminum ores, and potential aluminum resources should be continued. An outline of the phases of this research in which the Bureau of Mines could make important contributions is as follows:

1. INVESTIGATION AND CLASSIFICATION OF DOMESTIC RESERVES OF BAUXITE AND BAUXITE SUBSTITUTES

For intelligent planning of future research it is necessary to have a knowledge of the quantities of bauxite that can be extracted from United States deposits and utilized by established commercial processing techniques. Additional information is necessary to gain a more precise picture of total domestic reserves. A

classification system that will conform to current and anticipated uses should be developed and periodically revised to promote the most efficient consumption of domestic bauxite by the various consuming industries. This phase of the program should also include delineation and development of the bauxite clays and laterites and the most promising nonbauxitic aluminous materials.

2. MEASUREMENT AND CLASSIFICATION OF BAUXITE RESERVES IN THE WESTERN HEMISPHERE

If current plans are not interrupted by changing technology of economic conditions, the aluminum industry will continue to depend on bauxite from foreign deposits in the Western Hemisphere as the major source of ore. All available information on the bauxite reserves in all of the countries from which bauxite or products of bauxite can be obtained in the Western Hemisphere should be collected. Where feasible such information should be developed and collected from cooperative exploration projects with the countries involved.

3. IMPROVEMENT OF MINING METHODS

In many instances the domestic mining of bauxite is a selective removal operation in which ore regarded as undesirable at the time of mining is abandoned. This practice results in downgrading and devaluation of the remaining ore. An investigation of the problems associated with bauxite mining is necessary to provide recommendations leading to conservation and more efficient utilization of bauxite.

4. BENEFICIATION OF BAUXITE AND BAUXITE SUBSTITUTES

The aim of investigations on beneficiation should be the production of concentrates amenable to use in established processing plants with coincident recovery of byproduct commodities. The recovery of byproduct materials is not only a possible means for lowering production costs but in many instances is a means for conserving other mineral resources.

5. ALUMINA PRODUCTION

Although much of the basic technology required for recovering alumina from low-grade domestic ores is known, the conversion of this knowledge to industrial applications requires the development of equipment and plant designs. Also, modifications in known processes will be necessary for the treatment of each of the domestically available materials, and research on new processes should continue.

6. METAL PRODUCTION

Although the electrolytic reduction of alumina to aluminum has been practiced on a commercial scale for over 50 years, research is required for improving the efficiency of the electrolytic reduction process. Nonelectrolytic processes for production of aluminum should be investigated. Thermal reduction methods to produce master alloys have been developed. Investigations should be continued with the aim of producing higher quality products.

7. SECONDARY METAL RECOVERY

As the supply of old scrap increases the problems associated with metal recovery and utilization will also increase. Investigations for upgrading scrap and increasing recoveries should be continued.

8. COLLECTION OF STATISTICAL AND ECONOMIC DATA

The statistical programs of Government agencies and independent organizations collecting data on aluminum and bauxite industries should be coordinated so that statistics of the complete flow of materials from bauxite to finished products will be available.

Mr. BLUE. That completes my testimony.

Senator MALONE. Thank you very much, Mr. Blue. If you have any further information on costs or processes, or any other information you think would be helpful to the committee, we would appreciate it if you would submit it. We intend to keep in touch with you.

Mr. BLUE. All right.

Senator MALONE. We will recess for lunch and return at 1:30. Mr. Oliver Ralston will be the next witness.

Mr. Zinner, will Mr. Ralston's testimony complete the witnesses from the Bureau of Mines?

Mr. ZINNER. Except for the coal and petroleum.

Senator MALONE. Which we will not attempt to handle today.

On coal and petroleum, we will call witnesses after prior consultation with you when we return to resume hearings about the 16th of November. We have definitely set the two days, the 12th and 13th, in Salt Lake City, and will probably return here on the 15th. On the 12th and 13th at Salt Lake City we will hear producers of uranium ores. You remember that this committee heard evidence and recommended the modification of the Oil-Gas Leasing Act, and coordinated it with the 1872 Mining Act, so that the mining of uranium ores might proceed parallel to the development of oil resources of certain areas, particularly the plateaus located in Colorado and Utah. So in holding this hearing in Utah we considered Grand Junction, but it is a little inaccessible for some of the witnesses. So the hearings will be held, starting at 10 o'clock on the morning of the 12th, in Salt Lake City.

Then we will return and hear the coal and petroleum section of the Department of the Interior. I hope in the meantime that working ing with our counsel and engineer you can cover those fields, particularly the petroleum industry, the sources of synthetic production, as well as our domestic production and reserves of petroleum, and that will include the petroleum shales, oil shales, and the possible production of petroleum from coal.

Then, of course, the general supply of coal and the status of the industry will be covered.

If you can prepare for those hearings in the meantime, we will expect to hear you then, sometime right after the middle of November.

Mr. ZINNER. Mr. Chairman, if your committee will notify the Director of the exact date of such hearing, we will be very happy to supply that information.

Senator MALONE. Very well. We will return at 1:30 to hear Mr. Oliver Ralston.

(Thereupon at 12:20 p. m., a recess was taken until 1:30 p. m., the same day.)

AFTERNOON SESSION

Senator MALONE. The committee will be in order.

Mr. Oliver Ralston will be the first witness.

Oliver, we have counted on you to sum up in a general way the very excellent testimony we have received from members of your Bureau of Mines of the Department of the Interior. As you know, I have been familiar with the work of the Bureau in a general way for 25 or 30 years, and I have a high regard for the technical staff.

There have been times when I disagreed violently with the utilization of the information coming in to the technical staff, but it is my earnest opinion that the Bureau of Mines and the United States Geological Survey know more about the mineral industry in the United States and countries of the world than any other institutions.

I have been familiar with your work for that period of time at least, and I have looked forward to your second association with work I was trying to do, the first association being an encyclopedia of the 11 western areas and some other areas, including Alaska and Hawaii, starting in 1938.

You are familiar with the objectives of the committee which, under Senate Resolution 143, directs the Interior and Insular Affairs Committee to determine availability of critical materials to the United States in wartime. The Mineral, Materials, and Fuels Subcommittee has been directed to do the work and report to the main committee, Interior and Insular Affairs, which in turn will report to the Senate floor.

Many military strategists of my acquaintance believe it is going to be extremely difficult if not impossible to transport any quantity of such minerals, materials, or fuels across either ocean when world war IV, or whatever number they might give it, begins, because of submarine warfare, atomic bombs, and the ability of high-speed airplanes to destroy ports and harbors within any reasonable distance of their bases.

You have heard the testimony of all of your people, which, I believe, covered almost the entire range of minerals and materials.

The witnesses started from the top: The Secretary of the Interior and the Assistant Secretary, Felix Wormser; and then Messrs. Johnson, Melcher, Irving, Blue, Kline, and Josephson.

We will hear at a later date the experts from your Bureau on petroleum and coal, which will include the synthetic products and products from other materials, such as petroleum from oil shale and coal, and the availability of these fuels and the materials entering into their production.

The exhibit on page 45 contains almost a complete list of the strategic and critical minerals and some materials under the heading "United States: Actual and Impending Self-Sufficiency Based on Present Technologic and Economic Conditions and on Commercial Reserves, and the Potential Supply of Technologic Economic Changes Permitting Use of Known Submarginal Resources."

Under the heading "United States, Canada, and Mexico: Actual and Impending," under the same conditions, and under "Western Hemisphere: Actual and Impending, and the Potential Supplies," based upon the same assumptions.

This table is very gratifying to me. It is the first time I have seen a table worked out and based upon factual data.

Under "Potential," under "Western Hemisphere," there is quite a considerable list based on technological and economic changes that are in the offing and in the forseeable future.

The first list is under (*a*) virtual self-sufficiency; (*b*) complete or virtual dependence on foreign sources included only one element, industrial diamond; (*c*) under the potential of the Western Hemisphere, partial dependence on foreign sources, meaning across either ocean, foreign countries other than Western Hemisphere, includes cobalt, chromite, columbium, tungsten, and asbestos.

Would you, then, Mr. Ralston, in your own way and at your own tempo, just make whatever review of the testimony and supplement the information for the benefit of the record and the committee?

TESTIMONY OF OLIVER C. RALSTON, CHIEF METALLURGIST OF THE BUREAU OF MINES, DEPARTMENT OF THE INTERIOR

Mr. RALSTON. My name is Oliver C. Ralston, Chief Metallurgist of the Bureau of Mines of the Department of the Interior.

I have been quite pleased to see your subcommittee undertake this type of a study, looking forward to greater security of this Nation, because I have been through three wars, since I first joined the Bureau of Mines in 1912, and I have seen the problem of supply largely forgotten between wars.

Senator MALONE. That has perturbed many of us in the engineering profession.

Mr. RALSTON. I think we have had enough lessons on forgetting about this problem of supply until we need it.

Just along the general benefits of a war, war is not entirely lost to us. The Nation always grows rapidly under a stimulus, and particularly the scientific and technical fields are called upon for using every resource they have.

During the hearings of this committee in dealing with Bureau of Mines men you have repeatedly brought out the fact that we frequently discover deposits as a result of war urgency. But you don't hunt deposits until a demand exists, and it shows you something that you may need only temporarily or occasionally, but nevertheless there is that potential demand that you must be ready to meet.

I have seen in my own experience in the mineral industry in World War I two particularly rapid developments during the war, namely, the application of flotation to the concentration of ore which mushroomed from half a million tons of ore in 1 year treated by flotation to perhaps 150 million tons during the immediate couple of years following the war.

Senator MALONE. That is almost a fantastic increase.

Mr. RALSTON. Yes. It was due to war stimulus.

Senator MALONE. And to the necessity of greater production and therefore more laboratory work and experiments to determine the methods that could accomplish certain separations.

Mr. RALSTON. Yes. There was an even greater benefit in the case of the electrolytic-zinc industry. Apparently no electrolytic zinc was being made in the North American Continent except experimental at the beginning of World War I.

The electrolytic-zinc process was made by war exigency. It arrived much more rapidly than it would normally have done. Now, some years, as much as two-thirds of the world's output of zinc is electrolytic. It is much more efficient than the old thermal distillation of zinc from ores.

There were two mineral shortages in World War I that were particularly grievous that were corrected as the result of the war, but they were done between wars. One was the potash supply, and the other was the fixed nitrogen supply, both fertilizer, both in demand by a large number of voters who demanded that, for instance, potash, which had mushroomed from a price of $40 a ton of potassium chloride before the war, during the war up to $400 a ton, and there was not much of it. Fixed nitrogen was the other main fertilizer outside of phosphorus and was in as bad a condition. Both of those were corrected.

In the case of potash it was corrected by starting to explore. In the case of fixed nitrogen it was done by chemical research. Before another war came we were independent if we ever got into another war.

The potash exploration was conducted by the Geological Survey and the Bureau of Mines. By 1930 the Carlsbad, N. Mex., salt deposits were known though they had been greatly developed by further exploration.

The technology had to be studied and the Bureau of Mines had a rather large pilot plant study for several years. Industry got going on it, too, because the deposits were large. Here was something that was certainly going to have some kind of Government backing in order that the agricultural industry of the United States would not be caught without fertilizer again.

World War II benefited a great number of things, but the outstanding mineral material of the war that was brought to fruition was uranium.

Uranium now is almost a second gold to the mineral industry. There is a guaranteed price for a long period of time. That has sufficed to encourage all kinds of prospectors from the traditional tobacco-chewing, whisky-drinking prospector with his burro to exploration corporations.

The study of fission of uranium brought out the fact that the ashes of fission were mainly in the rare earth group of metals mentioned by Mr. Kline.

In even trying to analyze the ashes of fission and identify in quantity and quality all of the things that resulted from an atomic explosion, the technology of the rare earth metals was advanced a great deal. They had been so similar it was hard to analyze them.

It was very expensive for anybody to take a sample of the usual mixture and tell you how much of each thing was there, and he was not certain he covered the waterfront when he did make such an analysis.

Analytical methods are frequently the parents of industrial separation methods. Therefore we have increased our knowledge to a certain extent on how to separate those and there is now considerable activity. In fact, it was the studies resulting from the development of the atomic bomb on a uranium basis that have put nearly every element in the periodic table of elements to some kind of use. Some of them are very trifling, to be sure. That has broadened the number of metals that we are going to have to deal with. Some of them are new to us, new to industry, as new as titanium was 10 years ago or zirconium 6 years ago. They may replace some of the other things we now use and are short of.

In the Korean war, I think the Korean war really made titanium as an industrial product. I think it would have dragged on more slowly if through the lessons of the Korean war we had not decided we must have titanium for all three branches of the armed services.

Zirconium is beginning to share that responsibility and most recently, hafnium, the third of the three metals that are so much alike. Hafnium is at present made only in small amounts. What you might call the industrial use is entirely the Atomic Energy Commission who do have a definite use. I think we are going to find that some of the hafnium alloys are going to have high utility.

Up to a few months ago the hardest mineral substance outside of diamonds was boron carbide and we have measured hafnium and it is still harder and it approaches diamond.

Boron carbide is too brittle. We don't know too much about our hafnium carbide. It is not too pure yet and we don't know how tough it will be. It has hardness, but it must be tough. Diamonds have both properties. Hafnium carbide, by virtually being so hard, is going to have some uses.

Incidentally, it has the highest melting point of any mineral substance. It approaches the vaporization temperature of carbon.

Senator MALONE. What is that temperature approximately?

Mr. RALSTON. In centigrade degrees it is about 3,800°.

Senator MALONE. That is terrific heat.

Mr. RALSTON. Tungsten melts at about 3,500. There is something with a still higher melting point than tungsten. I am sure hafnium has been kicked up several steps on the stairs by a war emergency.

Korea, also, as we learned this morning, has brought the solution of the kyanite problem. The ceramic industry has benefited greatly because we have tried to replace some of the metals that burn in the combustion chambers of jet engines or in the nozzles of rockets too easily.

Some ceramic refractory and a combination of powder ceramic minerals with metals in what we call ceramets, to show the merits of the two, are giving us refractories that will give us service that no known alloy metal will give by the combination of their refractory qualities.

We have a wonderful series of dielectrics, semiconductors that have been put together through ceramics. We have a new branch of ceramics, you might say the ultra ceramics because of ultra fine uses.

I have heard it stated repeatedly here that from this list we have talked about it would look as though the Western Hemisphere is independent or can be made independent with the proper effort at not too far distant a date, of about everything but industrial diamonds.

Mr. Josephson mentioned rather shortly something that I want to expand on. There is a replacement of the industrial diamond to quite a large extent. I don't mean a synthetic diamond, I don't mean a substitute for a diamond; I mean let us do things some other way than we now do them with the industrial diamond.

I say that because that is just what is going on and believe it or not practically everything that has been done on it has been done by industry, realizing that there was a market for whatever they did because we never are going to have all the industrial diamonds we would use if they were available. Since we can't have all that we want, what else is there that we can do? That problem is going along beautifully.

Mr. Josephson may have put into his written statement the document that is available. That was a document prepared by the Minerals and Metals Advisory Board of the National Academy of Sciences.

They set up a panel. I was on the panel. The title will have to be supplied to you later and the number of the report, but it was on new processes of grinding very hard material. That is, grinding and shaping very hard materials. It is those things that now require the industrial diamonds. There have been about a dozen new processes or machines invented of which six look very good now.

All six are already in use on the evaluation basis in one or more machine shops. Machine shops that have good technical guidance. The results of the past year have been so good that the panel had to get out a supplementary report which is just coming out. The number of that report is not known.

Senator MALONE. Will it be available within the reasonably near future?

Mr. RALSTON. I think it is available now.

Senator MALONE. I wonder if you could make it available to the committee?

Mr. RALSTON. I shall channel it to you. I shall soon be going abroad but I shall make arrangements to see that it is channeled to your office probably through Mr. Josephson.

Senator MALONE. If you will send us a couple of copies we will mark it "Exhibit No. 1," supplementing your testimony at this point. It will not be included in the record, but will be placed in the committee's files.

Mr. RALSTON. Very well.

Mr. RALSTON. Now, as an example, so this testimony means something, a little bit of the technology should be described.

This is a method that can even bore holes in diamonds without the use of diamond dust. Diamond dust is the only thing hard enough to bore holes in diamonds.

The electrospark and the electroarc processes are two of these, either of which can bore holes in diamonds without any abrasive.

With a small tungsten wire you can spark between a tungsten wire electrode and the diamond that you are going to bore held as the other electrode, and a little spark at one spot superheats the diamond enough to spall out a little diamond and the next spark spalls some more until you can bore a very small hole through the diamond and thereby have a diamond die suitable to draw the wire.

You have not had to buy any diamond dust. You have created a little diamond dust in these spalls. You can use those to sharpen the edges of tungsten carbide tools now sharpened by diamonds and shaping hard-tool metals.

Those are only 2 out of 6 processes that come in to either replace the diamond itself or to work on the diamond itself or to do the same job that diamond wheels or diamond powder will do in abrading and in sharpening and in cutting.

Certainly, for wartime, they promise the displacement of the present diamond requirements. There will always be some particular jobs that will call for some diamond bort. But if we use these now known schemes that are being evaluated—some as many as 10 in 1 plant for evaluation against several hundred other machines doing their regular work—I am sure they will be usable in wartime and will take at least the hex off a part of this only commodity that still leaves you some trouble.

Senator MALONE. Would you be prepared at this time to estimate roughly what percentage of industrial diamonds might be displaced by these methods?

Mr. RALSTON. They classify the uses of diamond bort, for instance, in sharpening singlepoint diamonds themselves. They point out the extent to which you can get away from the use of bort to do it.

As much as they can predict from the present status, that has been put into those reports.

Senator MALONE. That is very interesting.

Mr. RALSTON. This latter report which supplements the earlier one and has much more in the way of exact data has come from the very rapid advancement. Those things are promising to go to town.

Senator MALONE. For example, one of the main things that prognosticators overlook when they make predictions, as they have for the last 20 or 30 years, that we have only so much of this and so much of that and our supplies will be exhausted in a certain number of years, is that they utterly ignore technologic progress through laboratories, inventions, and processes that often, as you are now testifying, partially or entirely displace some commodity that has been up to that time supposedly irreplaceable and indispensible; and also utterly ignore the discovery and evaluation of reserves when a reasonable profit incentive exists?

Mr. RALSTON. I feel anyone who now makes prognostications has always got to give himself an escape clause. Omitting consideration of possible technologic progress, here is what I predict. It is the big imponderable in anybody's prediction and we must not forget it.

Senator MALONE. You have heard the testimony here which has been very gratifying to me.

For the 25 or 30 years since I have been watching production in this country, and have been very much interested because it was part of my business, the less such men know about the matter the more prone they are to make predictions about the reserves of a certain material when they are temporarily in high office.

I know I have heard you explain it before. It is my long association with you which makes me interested in your testimony. I have a high regard for your technical information and experience.

Would you explain what is ordinarily meant by known reserves, and the danger of quoting known reserves to the public who have been led to believe over the last decade or so that these reserves are all the material we have in the United States of America, or in the Western Hemisphere, or any certain area?

Would you explain that phrase for the benefit of the people who will study this record?

Mr. RALSTON. When I as an engineer read a company's annual report and the reserves are mentioned, I feel that means the ore that they have blocked out on at least 2 dimensions, usually 3, that they have ready to mine.

There are no guesses as to what else may be in their mineralized ground. That means developed or proven ore. If they have any guesses they may have two dimensions, but they usually say the probable ore. That is the old term. The probable ore is so many more tons. In the old days that probably included all of what we now call indicated ore, and some of the inferred ore.

The geologist is entitled to infer ores of some kinds if there is a definite formation in which the known ore has already been shown and some of it indicated and could just as well have some more, particularly if he has showings here and there. But one swallow does not make a summer.

Here is a formation. Here it is pretty well blocked out. Here you have indications; you have seen some of it, so it apparently does extend there. That is inferred ore.

In coal seams, naturally coal seams extend long distances. We have a lot of inferred tonnage in the coal tonnage estimate. So when we reach the point of saying the national resources, we usually have all the inferences in. That is the other extreme of reserves.

The national resources are estimated to be so much. It includes a lot of estimates and guesstimates, but they are the guesstimates of experts.

Senator MALONE. Yes. Then when an inexperienced man, regardless of his high position—inexperienced in mining and technology applying to that particular industry—takes these reports and adds up the known ore reserves and says that is the supply in the United States of America and infers in a public speech or statement that we must save these reserves and import from foreign countries, he misleads the public, does he not, because he utterly disregards the fact that an operating company rarely develops more than 2 or 3 or 4 years' known resources? It would be economically impossible for an operating company to do otherwise.

The fact that today we have greater resources of a long line of ores and fuels like petroleum, tungsten, and other materials than we had in the First World War merely infers that there have been profitable operations which have continued to develop reserves; isn't that the story?

Mr. RALSTON. That is right.

You owe it to your reader, I think, these days, to use some adjective in connection with reserve. What kind of a reserve is it?

For instance, toward the end of World War II, the lead mines were running out of developed reserves. They had not been able to get enough miners. They could not keep their development work ahead. They knew they had mineralized territory, but where in it was there more lead?

That had not been shown. They could just stick in the deposits they were working. If they came to the end of those, was there an extension someplace else that had not been shown? Our own lead production was beginning to suffer due to having worked out the developed reserves and not having developed some more.

Senator MALONE. Isn't the development of reserves——

Mr. RALSTON. At the time we had practically zero reserves in lead at the end of the war.

Senator MALONE. Then I want to ask you as an experienced mining engineer, and one who watched as much mining development in the United States as any man I know, whether, in a going concern mining industry, there isn't a definite part of the profits of that going concern mining industry always set aside for the development of reserves?

Mr. RALSTON. It is the only sensible management that you can have. You must always have some reserves ready to mine.

Senator MALONE. Even a mining company may have a mining engineer following up discoveries in farflung areas in order to have available production when the reserves in the area in which they are currently mining are depleted.

Mr. RALSTON. Yes. Sometimes reserves have been partly developed by diamond drilling. You don't have all the story from diamond drilling.

The diamond drill may go through a little local horse in the deposit that would show practically nothing; and, on the other hand, you may go through the very richest part and think it is all that way.

So the diamond drilling always has its hazards in laying out your reserves.

Senator MALONE. It has to be a very careful job to really mine any minerals.

I have had some very interesting letters recently. You now have geophysical methods of determining the possible location of certain ores, and there has been quite a little pressure lately to have the geophysical expense included in the location work, which might have some merit.

Mr. RALSTON. Yes.

Senator MALONE. Go right ahead. I didn't want to interrupt your line of thought, but this is a very interesting field because it has been abused, in my opinion, over a period of years by people who have in mind bringing about a certain conclusion on the part of the public and simply take advantage of conservative statements of engineers and producers.

Mr. RALSTON. I think we have thrashed that out. I agree they should never mention reserves unless they have some adjective description.

Senator MALONE. For the public, if you simply added the reserves of the known mining companies, there ought to be some kind of explanation that is is a going-concern industry, and operating mining companies have always developed new reserves. The public should not be deceived into thinking that reserves are like sacks of sugar; when you get to the bottom of the sugar that is all there is in the entire supply.

Mr. RALSTON. That is right, sir.

Now, getting off the diamond, but still not getting off it, every one of these materials in which we have shortages there have been certain studies that have been made, usually by the temporary agencies that have been charged with control for various purposes.

In the case of diamonds the first thing to do was to study conservation in the use of the diamonds. How much wasteful use of the diamond were we guilty of; how much saving could we get by conservative methods of using them; and cautioning the machine-shop men against leaning too hard with a diamond tool and breaking it. "Here, fellow, you are only going to have a few of those this week; you have to make them last." That is a simple example of conservative use.

Then, to what extent are there replacements such as these new machine tools that I have just described? To what extent are there some of those things that could be used and not even use the diamonds? If they are not in sight, are there any substitutes for diamonds?

Lastly, can we synthesize diamonds?

There are those four steps—conservation, replacement, substitutes, and synthesis. All of those paths have to be studied and followed.

In the case of synthesis, this morning in connection with the nonmetallics of the two nonmetallic branches of the Bureau of Mines, there have been quite a few things that have been synthesized.

Asbestos is the thing we are now trying to synthesize. One kind of mica has been synthesized.

We talked about electrically welded alumina. Electrically welded alumina is synthetic corundum, but it does not have the exact qualities of Nature's corundum. It is more brittle. Sometimes it is not

quite so hard because you can't keep all the impurities out. Electrically fused alumina is really a synthetic corundum and has been in use on a large scale through all three wars.

It never has been quite as good as the natural corundum. So naturally the natural corundum has been used for the most discriminating purposes.

One of those mentioned was snagging castings. You have two wheels you can lean on and get the nub off the corner of a casting in a hurry otherwise you may be tempted to take a sledge hammer and knock it off and possibly ruin your casting.

But it still has to be an abrasive that will stand abuse and that is where the natural corundum comes in. Otherwise you can use the synthetic corundum.

Senator MALONE. Right at that point, if we are not able to transport the natural material from other nations, what percentage of the natural corundum that is ordinarily used in industry could very well be replaced by the synthetic corundum?

Mr. RALSTON. I think it all could be replaced.

If you had a machineshop doing a certain job and found you could get it done 25 percent faster with the natural corundum than you can with the synthetic, you would buy natural corundum up to the point where the saving in time was canceled by any other economic factors. It might not be exactly 25 percent.

In time of war you don't want to have to put in another 25 percent of machines into your shop if you can get all the work done. In wartime you are pressed for time above everything else. If you are going to lose 25 percent of your time, you are not going to do it until there just is not the stuff to work with.

Senator MALONE. Would you lose 25 percent of your time in much of the work? I have listened very closely to your description of it, and I understand there are certain phases of the work that might be almost as efficient.

Mr. RALSTON. Yes. Certainly then you have no justification for insisting on getting something imported.

Senator MALONE. But there is a certain proportion of the work where you would lose a little time by having to go a little easier with it?

Mr. RALSTON. Yes.

Senator MALONE. What percentage of the work would you say that you would lose?

Mr. RALSTON. I believe this morning it was mentioned that the exact proportion in the case of corundum is not known but I can tell you it is about 25 percent both on lens grinding and snagging.

Senator MALONE. About 25 percent would require natural corundum to do a good job in the minimum time, and the 75 percent could be done with the other product?

Mr. RALSTON. No. I meant that the time factor involved in doing a job of grinding lenses or snagging will be 25 percent longer if you use the synthetic product made at home.

Senator MALONE. In all cases?

Mr. RALSTON. I imagine that you won't find any two cases exactly the same. Let us say the average is 25 percent.

Senator MALONE. That is what I was trying to get at.

Mr. RALSTON. If you are over the barrel and can't get the imported material you are going to build more machines, employ more men if the manpower is available, or more women or boys, and if you get up against it you will get by.

Senator MALONE. And you can do it with the synthetic product?

Mr. RALSTON. Yes.

Senator MALONE. Right at that point, let us talk about the quantity. It does not deteriorate in the stockpile?

Mr. RALSTON. No.

Senator MALONE. That is the natural corundum. What quantities are involved in an annual consumption of corundum? What is the value of this amount?

Mr. RALSTON. It is very small. It would be four or five thousand tons a year. It is a product that is not easily stockpiled. That tonnage supplied by Mr. Josephson is a small one.

Senator MALONE. About 5,000 tons?

Mr. RALSTON. Yes. It does not cost very much in dollars if you get the extra 5,000 tons outside of your production from the mines.

The South African mines on corundum were pushed during the war and it was pretty hard to get the supplies just for the current needs. It is quite possible they were like the lead mines; they were called on for more and more corundum until they were out of proven reserves. Whatever the cause, it just was not available at that time to build a stockpile.

With smaller drafts on their supply at the present time, this is the time to build the stockpile and the time to do all of the war work for arranging for supplies or getting substitutes worked out. The time to do that is between wars.

Senator MALONE. Just as we are trying to do now.

Mr. RALSTON. Yes, sir.

Senator MALONE. I was going to say it is not an expensive thing to stockpile.

Mr. RALSTON. No; nothing like the copper stockpile.

Senator MALONE. Then during any period it could easily be transported by plane?

Mr. RALSTON. Yes.

Senator MALONE. Go right ahead.

Mr. RALSTON. I had some thoughts on the testimony of jewel bearings. Swiss labor is the thing with which we compete. There are very few of the Swiss who are grinding jewel bearings, mainly watch bearings, who make a complete bearing. There are very few of the Swiss who work in anybody else's shop.

The Swiss do their work in their own homes with simple, little machines. On watch bearings, the original mineral will first be sliced, say, with a diamond saw, and the slices will be cut up into little flat squares. That slicing may be done in two different shops, each operator renting his own machinery but doing it at home. His family can be in on it to the extent that they wish to.

Piercing, or for a V bearing where you do not pierce all the way through, may be done in a rough cut in one place, and then to a house in another village goes the polishing. It is done on a piecework basis. So much per bearing. They don't have to work every night or every day. In a Swiss hamlet, where they are farmers mainly or run cattle, if they are farmers they have a long winter spell when they can do a

good deal of work. In the summertime they may work only of evenings.

Senator MALONE. That would be what you would call decentralization of industry.

Mr. RALSTON. Absolutely. It is taken down into such small units you don't have to build a factory. It is peddled around by agents. They are called padrones in Switzerland. I don't know whether there is any opprobrium to the word "padrone," but in this country we would say local agents. The local agent is parceling out work to anybody who wants to do some homework to make a little extra.

That is what rural New England needs in the winters and doesn't have. It is the same thing with southern Appalachian Mountain people. They need that kind of work.

I don't know. We have not tried that kind of a system to see if we can work it out in competition. In New England we know that we have a lot of quite inventive people who may invent in their own homes something where they can do 10 times the work that the fellow does with the accepted little simple apparatus that everybody has.

Senator MALONE. In that area we also have some displaced watchmakers and people who might have an aptitude for work of that kind, do we not?

Mr. RALSTON. Yes. I think that description of Swiss labor needs to be in our literature here because we may get some ideas. That is talking about jewel bearings for instruments which are bigger as a rule. Instruments are usually bigger than watches.

General Electric Co. went through a shortage of instrument bearings in World War I. They found a Pennsylvania man who contracted to make their bearings and did a good job. After the war was over he had done pretty well. He went into a hearing—I think it was in the early stages of the War Production Board before it was named War Production Board. The dicker was made with him by General Electric Co.

They said, "Can you continue to make these, and will you estimate the cost?" He said he could continue and would be glad to for a certain figure.

The General Electric reply was this: "That looks too low. We are not certain you will stay in business. If we are dealing with you we want you to stay in business. Can't we raise this some?"

He was a good old Quaker. He said, "No, I am sure we can make an honest living and a profit with this bid that I made." So General Electric made a contract and hiked the amount to be sure to keep him in, and that man stayed in between wars all the time for them. They had their supply of instrument bearings.

Cost or no cost, American labor or Swiss labor didn't matter. General Electric had enough vision to be sure of its bearings for its instruments.

Senator MALONE. That is very interesting. There is no question in your mind, then, coupled with the testimony of the representatives of your Bureau this morning, that we can be, and should be, self-sufficient in the production of the jewel bearings in this country?

Mr. RALSTON. That is right. At the beginning of the war the delivered cost of the watch bearings was a matter of from 2 cents up to 5 cents apiece. For a 17-jewel watch, you had somewhere between 50 cents and a dollar's worth of bearings. That may not be cheap

enough for the dollar watches, but the 2-cent bearings were cheap enough for the dollar watches.

Senator MALONE. The dollar watches really do not have many jewel bearings?

Mr. RALSTON. No, they don't.

Senator MALONE. They are cheap watches. I think we are out of dollar watches. We have overcome that through inflation.

Mr. RALSTON. Now, how important is it to have 5-cent bearings in the 17-jewel watch? We know that the cost of the watch is so great compared to the bearings in it that we can stand a multiplied cost.

Senator MALONE. I am surprised they are that cheap.

Mr. RALSTON. You can still make your watches in wartime. If you have to have new watches, you can still make them, but they cost more.

Senator MALONE. But very little more?

Mr. RALSTON. Very little more.

Senator MALONE. That is very interesting.

Go ahead with your list.

Mr. RALSTON. We had some talk about the Cuban laterities. Nickel is a peculiar thing in that the mines that are already developed can produce more nickel than you can sell in peacetime. As soon as war comes along the demand spirals and you never have enough production capacity. The Cuban laterities are the biggest source of nickel in the world.

The proven indicated and inferred reserves of nickel in the 2 or 3 provinces of eastern Cuba amount to 24 millions of tons of nickel. If you see the list of tons of nickel from the rest of the world any place else, there is nothing that approaches it.

Senator MALONE. What is our annual consumption of nickel in tons, approximately?

Mr. RALSTON. That should be in our nickel testimony in this record, but not put in by me.

Senator MALONE. I just wanted to have it appear at this point in the record. Apparently in peacetime, say in 1940, it was about 160,000 tons. At the peak in wartime in 1943, it was probably close to 235,000 tons.

Mr. RALSTON. And that was not enough.

Senator MALONE. In 1952 it was about 200,000 tons. At least that is the range.

Mr. RALSTON. Yes. We never have enough. We always do as much substituting and conservation and replacement of nickel as we can.

Senator MALONE. I suppose that the reason for that is because most of the supply, except the secondary recovered supply of nickel, must be imported from Canada.

Mr. RALSTON. That is right. The Cuban deposits are leaner and in peacetime probably cannot compete with the richer deposits that are being worked elsewhere. Therefore, nickel out of Cuban laterite must be produced as a coproduct with something else. What else is there. It is mostly iron ore.

Senator MALONE. What is the percentage of iron ore in those mines?

Mr. RALSTON. It is richer than the average feed of blast furnaces in the Birmingham area and a little leaner than any of the northern furnaces.

But you can't make common steel out of the nickel-bearing iron ore. The big tonnage of steel in this country has no nickel in it and the nickel in most of the common steels makes them too tough or too stiff for working.

Again, in a machine shop you will only get a fraction of the output in a machine shop if you have a lot of nickel in your iron or steel.

Senator MALONE. I know here in 1952 it says that Canada produced 87.2 percent of our supply; Europe, 5.5 percent; Cuba, 6.7 percent; and the United States proper, six-tenths of 1 percent.

I heard some interesting testimony about an Oregon deposit where a contract has recently been let for nickel.

Mr. RALSTON. Yes.

Senator MALONE. In any case, the nickel supply is plentiful in Cuba.

Mr. RALSTON. Yes. The biggest reserve, inferred reserves, in the world, the biggest known deposit is the Cuban laterite ore on a high plateau some thousands of feet up in elevation, and about one-tenth of the so-called nickel is cobalt.

Taking the same tonnage of the ore, which is over 3 billion tons, that lean amount of cobalt makes it the biggest cobalt deposit in sight in the world.

Senator MALONE. That is a very interesting development because cobalt is a strategic mineral.

Mr. RALSTON. As an iron ore it is one of the largest deposits.

Senator MALONE. The chart prepared by the Bureau of Mines shows that in 1952 the consumption of cobalt was approximately 10,000 tons. The consumption has steadily been increasing.

The production in this country has been nominal but we imported last year, together with our production, around 16,000 or 17,000 tons. The greatest imports come from the Belgian Congo.

I am very much interested in your testimony as to what self-sufficiency we might reach in the production of cobalt.

Mr. RALSTON. Taking my figure, I said 24 million tons of nickel, that is really nickel plus cobalt. Ten percent of that is cobalt. That is 2,400,000 tons of cobalt that might take several generations to mine and use.

Senator MALONE. That is a lot of cobalt.

Mr. RALSTON. It is a lot of cobalt.

Senator MALONE. Considering the fact that we have not consumed more than approximately 8,000 to 9,000 pounds in our greatest year of consumption.

Mr. RALSTON. There is also in this material, chromium. The chromium content is about 2 percent. The chromic-oxide content on which we usually rate it is 2½ to 3 percent.

There is quite a little alumina in there that degrades the iron ore that would normally be 55 down to 45 or 40.

If we were to work the Cuban laterites for those 5 metals or 4 metals and alumina as a byproduct, not counting in the alumina, the gross value per ton of Cuban laterite was said to be about 24 and a fraction dollars. Most of that is the value of the nickel, cobalt, and chromium.

If we can dissect that ore and pull it to pieces and finally ship off iron ore without these alloying elements to be smelted in the United States, we have at our own back door everything needed for self-sufficiency in practically everything except possibly the chromium.

It depends on the scale we work with what we come up with on chromium. Up to date there have been no processes for doing that. There are four now being advanced through research on a pretty fair scale that is being test planted first. It is not really on a true pilot plant.

Senator MALONE. By the Bureau of Mines?

Mr. RALSTON. No, sir; that is private industry. The incentive seems to be there.

If you forget the iron value, if the iron would just pay its way from the mine to the furnace and you make all your profit on the other things, you have a proposition; but if you have to mine all that huge tonnage of what is mainly iron and some alumina oxide in it, and get nothing back for it, then you do not have a commercially profitable process on just the nickel, cobalt, and possible chromium values.

Senator MALONE. It is not profitable due to the competition at the time from other sources in the world?

Mr. RALSTON. Yes.

Senator MALONE. It is very interesting to me that you say we have right on our doorsteps all the supplies of nickel and cobalt we could ever need.

Mr. RALSTON. Yes. They won't cost too much over market price. It might be twice or three times if we load all the costs on those because the Nicaro operation, by the Freeport Sulphur Co. which set up the Nicaro Nickel Co.—it has had several changes of name during its history—and then relinquished it at the end of the war, produced nickel.

They let all the cobalt stay with the nickel and it was sold for the value of nickel and if it had been separated from the nickel it would have been worth more.

Senator MALONE. That is if the cobalt had been separated?

Mr. RALSTON. Yes. But cobalt performed the functions of nickel in most of the alloys in which the nickel went.

Senator MALONE. So this ore would be classed as a complex ore?

Mr. RALSTON. It is a metallurgical problem because of its complexity.

Senator MALONE. I mentioned once before in the hearing something that happened in the last 25 or 30 years. We had what was known as a complex ore in Piute, Nev., that contained several metals of sufficient quality or grade but there was no known method of smelting or separating the minerals.

Our mutual friend, Ed Snyder, one of the most persistent men in the mining industry, who has the mining fever that I often describe as a disease, worked on that problem for many years when many people thought he was wasting his time.

Then, when feasible process was developed the area became one of the largest zinc-lead producers in the United States.

Mr. RALSTON. That is right. That mine in Piute was known when I worked in our Salt Lake station for 4 years in 1918.

Senator MALONE. It was a known mine then?

Mr. RALSTON. Yes.

Senator MALONE. But it could not be operated profitably?

Mr. RALSTON. It was a problem. We regard the manganese as a problem.

Senator MALONE. If they work the mine, but not in competition with some foreign sources, with a differential provided for the wage standard of living between here and abroad, they are in the mining business for years?

Mr. RALSTON. Yes. The point I want to make about the Cuban laterities is that there is a huge source. The problem is still unanswered.

Fortunately we have four well-financed, well-managed enterprises individually looking at different processes which I can tell you are quite sophisticated metallurgy compared to anything that has been done on that or previously. All have certain problems, but all aim at recovery of at least 4 out of the 5; if they butcher anything it will be the alumina.

Senator MALONE. You say that the cobalt was included in the nickel. Was the cobalt ever separated?

Mr. RALSTON. No. It did its work which it can do in most alloys; the substitute for nickel. It is just a very expensive substitute.

It was built during the war in a hurry, had a lot of mistakes in the plant; it never reached its rated possible extraction. They jumped from a 1-ton-a-day pilot plant to 3,000 tons a day and, of course, made mistakes in the jump.

They never got the 90 percent extraction of nickel and cobalt that happened in the pilot plant. But it was done under war pressure and it got out some nickel. They got up to 70 percent extraction.

Senator MALONE. The cobalt and the nickel can be separated with known processes now. Under war conditions it could be done?

Mr. RALSTON. That is right.

Senator MALONE. And make the cobalt available in such quantities to make us independent in the production of cobalt?

Mr. RALSTON. I don't think anybody can point his finger at what is undoubtedly the best way of separating cobalt from nickel. There are commercial methods in use, each with some disadvantages.

That is one thing that would bear some research, purely technical research, on what is the most effective way of separating those. We have two dozen possible ways and are trying most of them, paper ideas or patents.

Senator MALONE. But through these known methods and the selection of the most feasible method, you could now go ahead and do it in time of emergency at a higher cost?

Mr. RALSTON. That is right. But why should we design something hastily put together, accepting the wrong equipment because the desired equipment cannot be delivered for another 18 months? All that kind of thing happens in war construction when you don't even have your process well worked out and pilot planted.

Senator MALONE. How long do you suppose, in your estimation, would it take if these investigations proceed in an orderly manner to decide on the best method and be ready to install the machinery to make this separation?

Mr. RALSTON. That is the type of problem that I regard as parallel or maybe an aggravated case of what the famous Mr. Kettering said about all new ideas going into the automobile industry. He said from the time they had an idea and decided to try it, until it went into an automobile in some form, took on an average of 7 years.

This is one of those things, if done right in an orderly manner, you have time enough to make mistakes, correct the trouble and go along until you find the next mistake and correct that until you finally have a good, smoothly operating pilot plant that seems to have no more mistakes in it.

Senator MALONE. But if during any part of that 7 years, if an emergency occurred you could pick out the best known process and at the sacrifice of some efficiency make yourself self-sufficient in cobalt?

Mr. RALSTON. Yes, sir.

Senator MALONE. I think that is the real nub of the question.

The matter of cost then can slowly be whipped into line and you would not need to adopt the process until the emergency arose.

Go right ahead.

Mr. RALSTON. Those were the points in listening to the testimony I thought I could add.

I have already put in my philosophizing about minerals for war at the beginning of this testimony.

Senator MALONE. As the chairman of the subcommittee, I hope you will either do the job or assist the expert in that particular area of minerals to do it.

In all cases, and there are several that we listened to during the past week, in our efforts to become self-sufficient in the production either in the United States or the Western Hemisphere and to increase our domestic production as much as is economically possible, I hope that you will, as I say, either do the job or cooperate with these departments in submitting to the committee in each case what should be done or continued, if it is now under way, in the way of laboratory work, pilot plants, or work in the field, including an estimate of the cost in each one of the scarce materials.

Where the work is necessary to be carried on to assure self-sufficiency at some reasonable price, or at least at a cost that would be comparable considering the difference in the labor cost and the price of materials here as against the sweatshop or low-wage labor country.

I have very little patience with people who advocate imports from the low-cost labor countries where they have few taxes, if any, or few safeguards for the workingmen, if any, and who urge such foreign production should be brought into direct competition with our own workingmen and small operations.

But whenever it can be done in this country or in the Western Hemisphere within the range of our standard of living and labor costs, I think we should continue these experiments and pilot plants and laboratory experiments and explorations—whatever is necessary—to bring that about for economic reasons. Then, whatever the cost, proceed along the line of making ourselves self-sufficient in time of emergency in domestic production, if possible, but certainly in the Western Hemisphere.

That is the theme you should carry around in a corner of your mind while they are rushing you around the world in the next couple of months, or discuss it with your people before you leave so that when you come back, or during your absence, even, these men could furnish the committee with this information.

Would you do that for us?

Mr. RALSTON. Certainly, sir.

After learning of the general result of this study of availability of materials in the Western Hemisphere that the answer seemingly is favorable—it is clouded with some doubts, but still attainable—I naturally have my thinking more warped in that direction.

Senator MALONE. At the risk of repetition I just want to say for the benefit of the record that I think you are one of the officials of the Bureau of Mines who has dedicated his life to this work; and the committee, if we may put it that way, is entitled to use your experience on the Senate floor in any argument or debate that might ensue as to the availability of these minerals and materials.

I want to congratulate you, too, because I know you have had something to do with the integrity and ability of the men who have testified here.

This was even surprising to me, this list of materials. As you probably know better than anybody else, I have spent a lot of my time on it in the last 20 years. It was done in my spare time; I had to make a living besides that. This work is a disease, apparently, just like the mining itself.

Considering your technological advancement and what has actually taken place over a period of years right under our eyes through discoveries, we have a list here that includes only one material, industrial diamonds, where we are completely or virtually dependent on foreign sources.

Your testimony today has been very helpful as to how great an area can be covered with other materials in emergency other than industrial diamonds.

We have a partial dependence on foreign sources of only six of these important materials—chromite, cobalt, columbium, tantalum, tin, tungsten, and asbestos.

Have we not arrived in sight of the answer or pretty close to it?

Mr. RALSTON. It looks that way. It looks like we have a good chance of hemispheric solidarity.

One thing I failed to mention, and since I have the opportunity, I shall, and that is that in the case of titanium the vision of doing the job was that of my predecessor in my present job. I inherited it at the time we had some titanium, but nobody interested in making titanium.

I made it my job to promote titanium, and the method of promotion was to go to those industrial enterprises that were known to be progressive and that ought to be able to use the material themselves or that were financially able to stay with it until they could sell the product. I don't think anything I did on the development of the technology was as important as finding the people that were interested, and started to risk their money in producing titanium.

Titanium is running on its own momentum now. It is going to go. I don't have to pay much attention to it. It is a thing that is answering some of the supply problems in the strategics because it can replace some of the other strategic metals.

Senator MALONE. What are some of the notable replacements that might be accomplished in the event there was a plentiful supply of titanium metal at a more reasonable price?

Mr. RALSTON. Take away some of the uses of stainless steel. That means saving nickel and chromium and columbium. We don't need

to put columbium into any of the titanium alloys. A lot of the stainless steels require an addition of columbium to stabilize the alloy.

Senator MALONE. You would not need any chromium in titanium?

Mr. RALSTON. Unless you alloyed it with titanium. But titanium to as high as 7 percent chromium would double its strength.

Senator MALONE. It already has the strength of double that of aluminum per pound, does it not?

Mr. RALSTON. Its strength weight ratio is six times as good as the strength weight ratio of aluminum.

Senator MALONE. Is it greater than steel?

Mr. RALSTON. Taking stainless steel, that is a rather strong steel, the commercial grade of titanium is just about on a par with it. When you alloy it with a little chromium you can make it twice that factor.

Senator MALONE. The same weight of titanium alloyed with chromium would be twice as strong as stainless steel?

Mr. RALSTON. Yes. And it would weigh only a quarter as much.

Senator MALONE. But it would be as strong——

Mr. RALSTON. You would only need to use a quarter as much per pound of metal.

Senator MALONE. That is what I am trying to develop for the record.

The same amount of chromium that you use in making stainless steel, when used with titanium, would be tremendously more effective.

Mr. RALSTON. That is right.

Senator MALONE. I would like to know that ratio.

Mr. RALSTON. It would put it in a better metal as an alloy.

Senator MALONE. What is the percentage of chromium in chrome steel ordinarily?

Mr. RALSTON. In stainless steel it is 18.

Senator MALONE. I think I was thinking of stainless steel.

Mr. RALSTON. Armorplate is a chromium steel, really, with some other thing in it. Armorplate is rather complex. It is more like 3 or 4 percent chromium in armorplates that we know.

Senator MALONE. Stainless steel would be 18 percent?

Mr. RALSTON. Yes. There you pile it in.

Senator MALONE. Does this ratio of strength hold good, that one-fourth weight of titanium——

Mr. RALSTON. Of alloyed titanium.

Senator MALONE. With 7 percent chromium, would be as strong——

Mr. RALSTON. Would be twice as strong.

You get the same amount of strength out of one-fourth of the weight of the alloyed titanium that you would get out of stainless steel.

Senator MALONE. So, with 7 percent chromium in the titanium you would get four times the strength?

So this record can be understood by the members of the committee, many of whom are not trained in this business, if you have a 7 percent titanium you would have 4 times the strength of an 18 percent chromium stainless steel?

Mr. RALSTON. Yes.

You get 10 times as much useful effect for definite weight of chromium put into titanium as you do into stainless steel.

Senator MALONE. That is what I was looking for.

In other words, if the chromite is scarce and you really want to make efficient use of it in airplanes——

Mr. RALSTON. Titanium would get allocated more chromium than stainless steel.

Senator MALONE. That is correct. We are now facing a situation we never faced before, and which you always do. That is how you continually move ahead in your laboratory experiments.

Never before have we had in front of us the possibility of having all the metal that has the qualities of titanium. We are going to Los Angeles to hold 2 more days of hearings and then we will hear the du Pont people when we come back, not because we know more about titanium than anybody, but the committee, I believe, can be helpful in bringing together the national defense users, the commercial users and the producers; because what we lack now is sufficient contracts, sufficient power and sufficient facilities to turn out the amount of chromium that has already been testified we need.

So that, to my point of view, is the prerogative of the committee.

Your testimony is very important in that regard. Do you have any further examples?

Mr. RALSTON. Nothing that occurs to me.

Senator MALONE. I would appreciate it personally, speaking as one member of the committee and I am sure I am speaking for the committee, if before you leave, you would furnish any further information that occurs to you. Then when you come back I will look forward to a discussion with you. But the advantage of leaving any dictated material that occurred to you would be that it would be included in the record and studied before you get back.

Would you do that for us?

Mr. RALSTON. Thank you, sir. I am sure that any technical man who may have a hot idea that ought to go into such a document as this will grab the opportunity to do it, and I shall.

Senator MALONE. Thank you very much.

(Whereupon the hearing was adjourned.)

APPENDIX

[S. Res. 143, 83d Cong., 1st sess.]

RESOLUTION

Resolved, That the Senate Committee on Interior and Insular Affairs, or any duly authorized subcommittee thereof, is authorized and directed (1) to make a full and complete investigation and study of the accessibility of critical raw materials to the United States during a time of war; (2) to study and recommend methods of encouraging developments to assure the availability of supplies of such critical raw materials adequate for the expanding economy and the security of the United States; and (3) to report to the Senate at the earliest possible date, not later than January 31, 1954, the results of its investigation and study, together with its recommendations.

SEC. 2. For the purposes of this resolution, the committee, or any duly authorized subcommittee thereof, is authorized to employ upon a temporary basis such technical, clerical, and other assistants as it deems advisable, and is authorized, with the consent of the head of the departments or agency concerned, to utilize the reimbursable services, information, facilities, and personnel of any of the departments or agencies of the Government, or of qualified private organizations and individuals. The expenses of the committee under this resolution, which shall not exceed $37,500, shall be paid from the contingent fund of the Senate upon vouchers approved by the chairman of the committee.

[S. Rept. No. 689, 83d Cong., 1st sess.]

The Committee on Rules and Administration, to whom was referred the resolution (S. Res. 143) to investigate the accessibility and availability of supplies of critical raw materials, having considered the same, report favorably thereon with amendments and recommend that the resolution, as amended, be agreed to by the Senate.

The general purposes of the investigation authorized by the provisions of this resolution are explained in a letter from the chairman of the Interior and Insular Affairs Committee to the chairman of the Committee on Rules and Administration, dated July 21, 1953, as follows:

JULY 21, 1953.

To: Senator William E. Jenner, chairman, Senate Committee on Rules and Administration.
From: Senator Hugh Butler.
Subject: Senate Resolution 143, authorizing a full and complete investigation and study of the raw-material situation of the United States by the Senate Committee on Interior and Insular Affairs.

In the opinion of our committee this investigation may be one of the most important for its effect on American security, ever to be held by a congressional committee.

Much of our present national policy is based on the assumption that the United States is definitely a have-not nation in respect to a considerable number of vital and strategic raw materials. This contemplation has had a direct bearing on the conduct of our foreign policy. It has led us to underwrite the fiscal systems and world policies of various foreign states whose friendship is deemed of the greatest importance due to their possession of raw materials which we are believed to lack.

The subcommittee has made a preliminary study of 38 of these minerals, as well as 3 fuels and 30 essential nonmineral materials, embracing many months of research. The results seem to make it clear that a careful inquiry should be made into the entire question.

As the matter now stands there is every possibility that an aggressive adventure aimed at the destruction of this country may become attractive to the Russians on the simple score of a feasible short war. The strategic motivation would rest on an effort to cut off the United States from critical raw material sources essential to its industrial plant, and hence to its ability to wage war.

It is well known that our existing Armed Forces in-being are wholly insufficient to act as a deterrent to Soviet aggression. Armed Soviet might outweighs us in every single department, with the exception of surface vessels plying the seas. In the event of open hostilities the first rush of Soviet offensive is certain to carry Soviet arms victoriously over a great deal of additional or peripherial territory.

It is recognized that our great military potential lies in our ability to mobilize our tremendous productive resources for the long pull. In the end it may be assumed that we will overwhelm Soviet arms as we did those of the German-Italo-Japanese Axis, by the sheer mass weight and quality of the war materials which will beturned out by our mills, factories, and plants. No such potential exists at the disposal of the Kremlin. In making its military calculations the Kremlin is forced to consider that in any test of strength, where the time factor was an element, it would ultimately lose.

Obviously this advantage accruing to our superior technology would be liquidated if our access to critical materials were limited or destroyed. By striking at the feeder lines to our industrial plant the Soviet could consider that it would immeasurably enhance its ability to emerge victorious.

Such a prospect would appear immensely more attractive to the masters of the Kremlin than an attempted decision by pitched battle, or an effort to attain decision by atomic attack.

World War II provided an object lesson into the possibility of reducing an enemy by economic siege. The effect of a strictured supply of such relatively unimportant materials as kapok and quinine were strongly felt. The effect of the loss of our rubber resources was for a while critical. Our ability to compensate for this deficiency by the use of synthetic rubber proved a factor of the greatest consequence in our conduct of the war. Similarly in World War I the achievement of the great scientist, Fritz Haber, in extracting nitrates from the air, saved Germany from an early and crushing defeat, allowing her to continue the struggle for 2 additional years.

It is rational, therefore, to conclude that to deprive the American productive plant of the full flow of raw materials essential to its needs, would be to place our Nation under the most desperate possible siege, eliminating at a stroke the enormous advantage we held in World Wars I and II, in which our superior technology and industrial organization provided the key factors to victory.

All of this bears with obvious importance upon the question of our national security and the possible strategy open to us. It is a matter which is sure to enter into enemy calculations. One of the great goals of Russian strategic operation could very well be the delivery of a lightning blow at our raw-material sources, in an effort to liquidate our capacity to fight a long war. Since a war with the Soviets may very well be an interminable affair outlasting in terms of time any feasible stockpile program we presently visualize, it seems mandatory that examination be made into the availability of all minerals and other materials in which we may be in short supply. This applies particularly where these materials originate in areas which cannot be strategically safeguarded by our forces and those of our allies, or which involve long hauls under conditions where safe conduct over the sea pathways cannot be guaranteed.

The question of guaranteed access to materials known to be on the critical list is not a simple but a complex one. Under today's conditions many factors must be equated, including the political climate which applies to the area of supply, the defensability of the supplying areas under wartime conditions, and our ability to protect the supply routes by which delivery would be made to our ports of entry. It is necessary to consider the problem in terms of hostile as well as peacetime conditions. We must also consider the position as it would exist if we were forced back directly to the defense of our own hemisphere. The situation then would relate not only to our true potential, but to the time factor, which involves exploration, investigation, training, and necessary investment. Thus, we are compelled to consider the economic logic under which such mining operations as lead, zinc, copper, mercury, and tungsten are forced to compete with foreign exporters of these materials, and the effect on the ability of American mine operators to survive. Thus comparative working conditions and standards of living the world over are of direct security interest within the scope of this investigation. The protection which may or may not be given to American operators becomes an important and possibly a decisive factor.

Among examples along this line, at a moment when the United States is using the greatest amount of lead and zinc in its history, our lead and zinc mines are closing down, unable to meet in our own domestic market the competition provided by Eurasian competitors. This raises the serious question of the time factor required to reopen these mines if necessity arose. In many cases the shafts would be flooded; engineers would have to be found, as would workmen. It is conceivable that the effort to reopen these mines for effective full-scale operation would take as much as 5 years.

An example in another direction is mercury, in which we are said to be singularly deficient and on which we rely principally on Spain and Italy for our sources of supply. Our researches indicate that there is plenty of mercury on this continent but that the mines have never been developed since the American producer cannot compete with the great European cartels for our own markets.

Attention may be called to many other materials, such as manganese. The latter is known to be in plentiful supply in Brazil, though here again a time factor is involved, demanding the construction of roads, railroads, smeltering plants, etc., creating a strangling problem of delays under the high pressure bottleneck conditions which might apply in wartime.

In addition there must be considered the political conditions which might apply to the States in this continent, which create an unfavorable climate for quick availability of needed raw material resources in wartime. An illustration here might be Chile where much wrangling is going on with the Government over the price demanded, or Bolivia, where nationalization of the mines and deep suspicion of the United States, do not offer favorable conditions for the swift replacement of our tin supplies should we be cut off from our present sources—southeast Asia.

A number of studies have been made seeking to develop and clarify the raw-material pattern as it would exist under critical or wartime conditions, and attempting to relate this pattern to our military goals and the needs of our industrial establishment. These investigations have operated from the viewpoint of legal access as guaranteed by treaty relationships with friendly foreign states.

There is a tendency to assume somehow that such de jure access confers a guaranty of continued availability even under the special conditions created by war. Our experience in the last war, especially after the Japanese invasion of the South Pacific, teaches us how dangerous and fallacious such an assumption might be. Yet it is on exactly such an assumption that the present strategic policy of the United States is largely based. It is this concept which provides much of the reason for our continued support of the fiscal and strategic positions of certain foreign states, as well as for our actions in the more direct terms of immediate American interest. The existence of tungsten in Korea, for example, is assumed to be an important factor in our determination to hold the southern end of that peninsula. Similarly our relations with the Belgians are judged of such vital moment, due to Belgian possession of uranium sources in the African Congo, that support of Belgium's economy must be considered a fundamental of American policy.

Such investigation as we have made indicates that there is probably more than sufficient uranium on this continent to supply all of our possible needs for many generations to come. In tungsten, a critical mineral of the greatest importance, practically all of which comes to us from distant foreign sources, it is probable that there is sufficient ore in the State of Nevada alone to fulfill all of our industrial requirements for the entire predictable future.

We are confident that investigation will show that under conditions of proper encouragement and development, little exists in the long list of minerals and other materials in which we are reported to be so deficient as to rely utterly on foreign sources, which cannot be found in this hemisphere. The important exception at this moment seems to be chrome, for which we rely on Turkey for our supply. Others are corundum, an important abrasive, industrial diamonds from Africa, and graphite from India. Even here, inquiry and stimulated exploration may be expected to elicit alternate sources of supply in our own hemisphere. Certainly it would be a major advantage to our national security if the net list of critical raw materials imported from faraway places were brought down to the smallest possible number, allowing for a long-term stockpiling which would be hardly feasible where the have-not list extends widely in many directions.

One of the major factors which must be considered in regard to our access to raw materials is the ability of our Defense Establishment to protect the produc-

ing areas in wartime. Careful evaluation of this matter with leading American military experts casts grave doubt on our capacity to do so. It is authoritatively believed that none of the peripheral areas bordering on the Russo-Chinese-Eurasian power sphere can be held by us under circumstances of all-out war.

Some insight into the position may be gained from the United Nations adventure in Korea, where a full third of the American military forces has been engaged in a violent struggle with forces representing at most a third-rate extension of the Soviet power apparatus. A similar view may be gleaned in southeast Asia where the cream of the British and French armies have been struggling for years without marked success against local guerrilla contingents. No one doubts for a moment that were these guerrilla armies joined by the Chinese and Russians, the areas in question could not be held for more than a matter of days or weeks.

The situation derives from one of the most important factors in modern war, the advantage of geographic space and position, as well as advantage in terms of available manpower. The Soviets control an area embracing practically the whole of central Eurasia, ideally situated strategically and containing almost 900 million people. Their central position in Eurasia guarantees the most highly effective lines of communication as compared with our own, which would be long, tenuous, and dangerously situated on the rim of the Soviet power wheel. The Soviets also would be more heavily armed in terms of existing armies, armor, and planes, than any forces the free world conceivably could bring to bear against them.

Those with whom we have consulted, who in our opinion represent the most informed and ablest military minds on this continent, held forth no hope that the peripheral areas of Europe and Asia could be held against the first onslaught of massed Soviet power. In the event of all-out war we would be certain, therefore, to lose at once our access to all minerals and materials originating in these zones.

An equally important consideration is the difficulty of transporting these materials across hostile seas.

It will be remembered that during the last World War the Germans almost succeeded in severing our sea communications with our European allies and in this manner bringing the war to an expeditious end.

In this reference it should be noted that the Germans at no time possessed more than 150 working submarines at the most effective period of their undersea campaign. Moreover, these submarines, as dangerous as they were, possessed many deficiencies as compared to new modern types. They were compelled to surface frequently, were slow and susceptible to the technique worked out by the British and American Navies for locating and destroying them.

The Russians are reliably said to possess a fleet of some 350 of these undersea craft. Many of these are of the very newest types, built from the latest in German discovery and design. These submarines, not yet in being when the war ended, are equipped with snorkel breathing devices which enable them to submerge for weeks at a time, and causing the problem of location for our Navy hunter-killer teams to become acute. They are fast enough to outrun most surface carriers. Equally as important, they can fire their torpedoes well out of sonar range, adding immeasurably to their effectiveness as an attack instrument.

Again, the military thinkers with whom we have consulted concede the grave possibility that our capacity to protect cargo and merchant carriers against these predatory killers in wartime leaves much open to doubt. Certainly one must accept the grim possibility that we will not be able to guarantee the safe movement of supply vessels between distant foreign ports and our own.

These are considerations which must be applied not only to the import of strategic materials from southeast Asia but from Europe and Africa as well. They are compelled to change our concept of the wartime universe, and especially of the needs of our wartime industrial base.

The preliminary examinations of the subcommittee provide distrurbing evidence of dangerous national misconceptions in regard to our raw material position. Our inquiries have also brought information leading to the possibility of effective corrective measures, principally related to the development of raw material self-sufficiency on the American continent.

Whatever the facts may be, it is of the utmost importance that they be determined, and that they be related to an exact evaluation of the strategic realities, as well as our own raw material potential.

It is considered that in conducting this investigation the committee will discharge an urgent and required duty and that its findings will be of the utmost importance in aiding those agencies of Government charged with formulating the military and foreign policies of our Nation, furnishing them with a body

of factual and informative material, additional and supplementary to that derived from the usual official channels.

It is intended to hold hearings on this subject, both public and executive as the situation requires, beginning in the third week of September and staff has already been chosen for this purpose.

Sincerely,

HUGH BUTLER, *Chairman.*

An amended budget, in the amount of $37,500, offered by the Committee on Interior and Insular Affairs to the resolution, and one approved by the Committee on Rules and Administration, is as follows:

UNITED STATES SENATE,
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
July 22, 1953.

Hon. WILLIAM E. JENNER,
Chairman, Rules and Administration Committee,
Senate Office Building, Washington, D. C.

DEAR SENATOR: Pursuant to your request of today, I am attaching herewith copies of the proposed budget of the committee to January 5, 1954, under Senate Resolution 143, submitted to the Rules and Administration Committee today, prorated to January 5, 1954.

As covered by the resolution, our committee is seeking an appropriation of $50,000, for the purpose of continuing its study and investigation into the accessibility of critical raw materials to the United States under possible wartime conditions, with particular reference to this country and to the Western Hemisphere.

It is intended to report to the Senate not later than January 3, 1955, on the results of this investigation to date and study, together with the recommendations of the committee.

It will be noted that our total prorated budget up to January 5, 1954, will come to $37,500. During the months of preliminary study in which our background material has been assembled, the committee achieved certain economies in operation, which it expects to continue during the more difficult work of hearings and travel investigation. We have been materially assisted by the fact that we have had and will continue to have the full-time assistance of outstanding Americans who are willing to place their services at the disposal of the committee without salary or other recompense. This includes chief counsel, the general advisers, and the top executive adviser to the committee.

In regard to the attached budget I wish to point out that 75 percent of our total expenditure is expected to be made during the next 5 months of our activity.

Our travel budget and associated costs will be especially heavy since it may involve hearings in Denver, Salt Lake City, Albuquerque, and other places where experts in the production of certain minerals are available, in order to get on-the-spot estimates and the fullest benefits of expert testimony.

In the period following, we expect to be able to dispense with much of the expert services and to reduce the balance of our staff.

We will appreciate word from you at your earliest convenience, so that our committee may continue its activities as planned.

Sincerely,

HUGH BUTLER, *Chairman.*

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